This document includes the Draft Surface Vessel Bilgewater/Oil Water Separator Discharge Assessment Report for the Uniform National Discharge Standards Program. The reference number is: EPA-842-D-06-005

# DRAFT
# Discharge Assessment Report
# Surface Vessel Bilgewater/Oil Water Separator

June 2003

**DRAFT**

# DISCHARGE ASSESSMENT REPORT

## *SURFACE VESSEL BILGEWATER*

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# 0.0 INTRODUCTION

Section 312 of the Federal Water Pollution Control Act [also known as the Clean Water Act (CWA)] requires that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for "…discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces…" [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase determined which vessel discharges require control by marine pollution control devices (MPCDs). MPCDs can be equipment, alternative materials, or management practices. The second phase (which this report supports) characterizes each discharge and evaluates the environmental effects and feasibility of implementing MPCDs for each discharge that requires control. The final phase will determine the design, construction, installation, and use of the MPCDs.

Discharge Assessment Reports (DARs) are prepared for each vessel discharge requiring control, as listed in Title 40 Part 1700 of the Code of Federal Regulations (CFR). A DAR is a summary of discharge-specific analyses conducted during the second phase of UNDS. The purpose of the DAR is to present key features of a discharge to allow the balancing of the seven statutory considerations to produce a performance standard. The seven considerations are:

- The nature of the discharge.
- The environmental effects of the discharge.
- The practicability of using the MPCD.
- The effect that installing or using the MPCD would have on the operation or the operational capability of the vessel.
- Applicable U.S. law.
- Applicable international standards.
- The economic costs of installing and using the MPCD.

Complete technical analyses of the surface vessel bilgewater discharge can be found among various documents cited throughout this summary, including:

- *Vessel Grouping and Representative Vessel Selection for Surface Vessel Bilgewater/Oil-Water Separator Discharge* (Navy and EPA, 2001a).
- *Characterization Analysis Report: Surface Vessel Bilgewater/OWS Discharge*, hereafter referred to as the Bilgewater Characterization Analysis Report (ChAR) (Navy and EPA, 2003a).
- *Feasibility Impact Analysis Report: Surface Vessel Bilgewater/OWS Discharge*, hereafter referred to as the Bilgewater Feasibility Impact Analysis Report (FIAR) (Navy and EPA, 2003b).

- *Environmental Effects Analysis Report: Surface Vessel Bilgewater/OWS Discharge*, hereafter referred to as the Bilgewater Environmental Effects Analysis Report (EEAR) (Navy and EPA, 2003c).

- *Environmental Effects Analysis Guidance for Phase II of the Uniform National Discharge Standards for Vessels of the Armed Forces*, hereafter referred to as the EEA guidance manual (Navy and EPA, 2000a).

A review of applicable U.S. laws and international standards (Section 1.2) and cost effectiveness information that relates the results of environmental effects to feasibility analyses are also topics in this report.

## 1.1 SURFACE VESSEL BILGEWATER/OWS EFFLUENT DEFINITION

The bilge of a surface ship is the lowest inner part of the interior hull where liquid drains from the interior spaces and the upper areas of the vessel (EPA and DoD, 1999). All vessels generate bilgewater and most commissioned Armed Forces vessels are fitted with oil water separator (OWS) systems to reduce the discharge of oil, in accordance with OPNAVINST 5090.1B).

## 1.2 APPLICABLE U.S. LAWS AND INTERNATIONAL STANDARDS

### 1.2.1 Introduction

The UNDS regulatory development process was designed to consider the seven rulemaking factors discussed in the main introduction. Two of the seven factors relate to applicable or relevant U.S. laws and international standards to provide a basis for comparison while developing UNDS performance standards. Accordingly, consideration was given to existing laws and standards relevant to the development of surface vessel bilgewater performance standards. Listed below are short descriptions of those laws and standards.

### 0.0.0 Relevant International Standards

The International Maritime Organization (IMO) held the International Conference on Marine Pollution in 1973, which adopted the International Convention for the Prevention of Pollution from Ships. This Convention was subsequently modified by the Protocol of 1978, and is known in short form as MARPOL 73/78. Standards covering the various sources of ship-generated pollution are contained in the five Annexes of the Convention.

Annex I applies to the prevention of pollution by oil and contains separate regulations for oil tankers, non-tankers 400 gross tons[1] and above, and non-tankers below that limit. MARPOL 73/78 exempts warships and naval auxiliaries from compliance but does require appropriate measures to be adopted (without affecting operational capability) to comply with the

[1] Vessel size is often expressed in terms of *gross tonnage* and *net tonnage.* Counter to the way it sounds, this term is an expression of the **volume** within the vessel **– not** the mass of water the vessel displaces. In this case, 1 ton = 100 $ft^3$. *Gross tonnage* is essentially the volume within the hull and superstructure.

Convention in so far as reasonable and practicable. The international standard, following the 1992 amendments, is summarized below. (IMO, 1978 and 1992)

- *For non-tanker vessels ≥400 gross tons:* Regulation 9 (I)(b) allows for the discharge of oil if the following conditions are met: the effluent without dilution does not exceed 15 ppm, the ship has a discharge monitoring and control system, the ship is underway, and the ship is not in a special area (as defined in Regulation 10).

- *For non-tanker vessels <400 gross tons:* Regulation 9(II) allows for the discharge of oil if all the conditions listed for non-tanker vessels > 400 tons are met, otherwise the vessel must be equipped (as far as practicable and reasonable) with installations to ensure the storage of oil residues on board and their discharge to reception facilities.

- *For an oil tanker:* Regulation 9(I)(a) allows for the discharge of oil if all the conditions listed for non-tanker vessels ≥ 400 tons are met except for oil from cargo pump rooms or oil from machinery room bilges that are contaminated with cargo fuel. MARPOL provides separate conditions that must be met in the case of these two exceptions.

### 0.0.0 Relevant U.S. Laws

The CWA § 311(b)(3) prohibits discharges of oil or hazardous substances in harmful quantities into the navigable waters of the United States and the contiguous zone. The Act to Prevent Pollution from Ships (APPS) (Title 33, United States Code, Sections 1901-1911) implements MARPOL 73/78, and thus has the same exemption for military vessels (i.e., reasonable and practicable compliance).

In addition to Federal laws, State numeric and narrative water quality standards are set under the authority of the CWA § 303(c). These standards normally apply to specific water bodies and vary by designated use. States use their standards to regulate both point source and non-point source discharges.

Under 33 U.S.C. 1322(n)(6), States and their political subdivisions are prohibited from adopting or enforcing any State or local statute or regulation with respect to the discharges identified in Phase I as not requiring control. In addition, once performance standards are promulgated (Phase II) and requirements for designing, constructing, installing, and using the MPCDs are established (Phase III), the UNDS statute expressly preempts States and political subdivisions of States from adopting or enforcing any State or local statutes or regulations regarding discharges identified as requiring control. The State's only recourse is to apply to EPA to establish no-discharge zones for specific discharges of concern in their waters.

# 0.0 VESSELS GENERATING SURFACE VESSEL BILGEWATER/OWS EFFLUENT

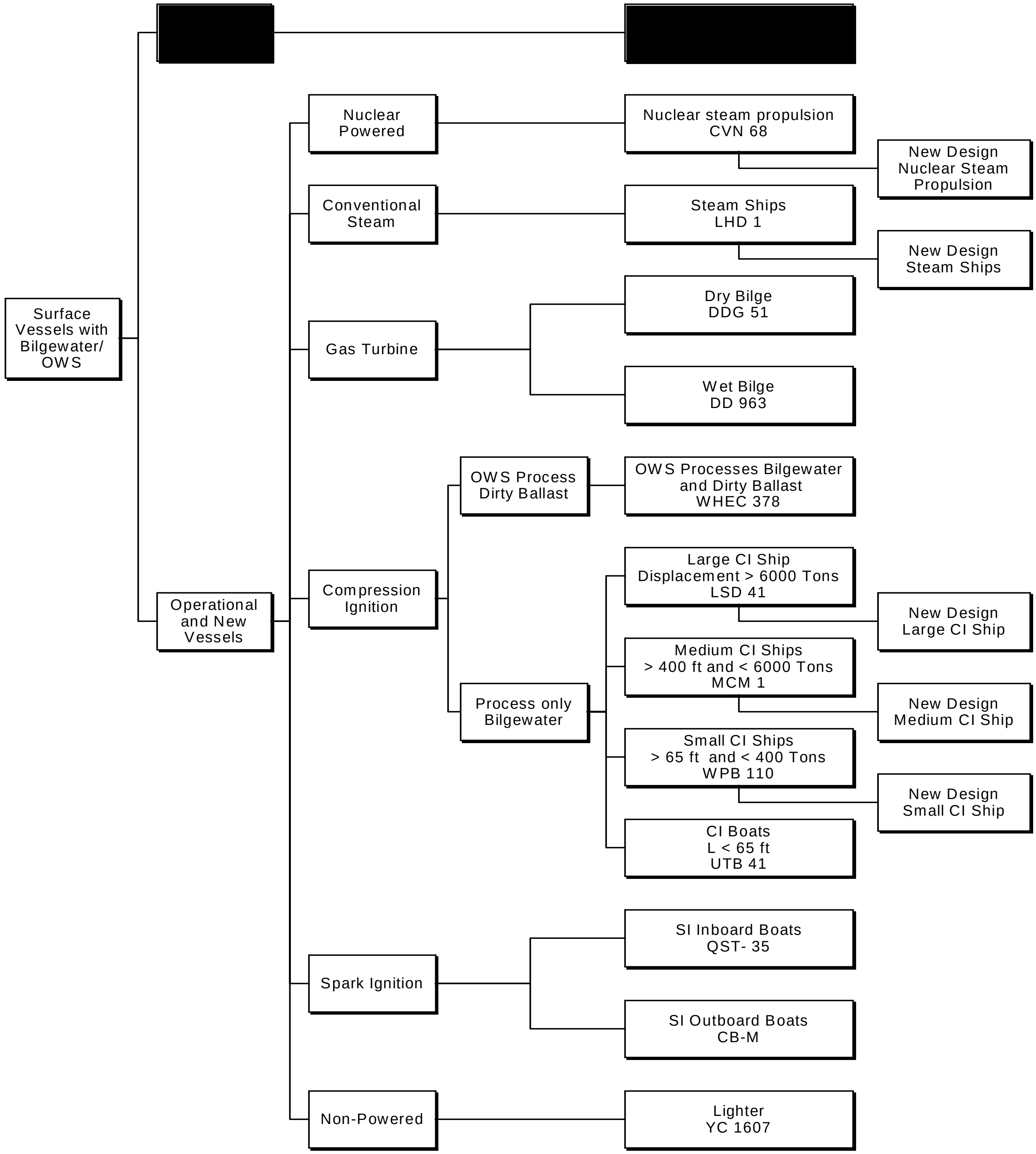
## 0.0 INTRODUCTION

To facilitate the feasibility and environmental effects analyses (EEA), and due to the large number of vessel classes and designs, Armed Forces vessels were sorted into vessel groups according to similarities in engineering and discharge characteristics. Vessels that produce bilgewater/OWS discharge were sorted into vessel groups using a tiered process. The discriminating factors in this tiered process included the following: surface vessels that produce bilgewater/OWS discharge, vessel operational status, type of propulsion system, bilgewater and dirty ballast processing, vessel size, type of bilge, engine placement, and new designs. A representative vessel class was selected for each vessel group based on how accurately it depicts the group's characteristics.

## 0.0 BILGEWATER VESSEL GROUPING DOCUMENT SUMMARY

Figure 1 shows how the tiered process described above resulted in the 13 vessel groups and representative vessel groups chosen for this discharge.

**Figure 1. Bilgewater Vessel Groupings**




For complete details of bilgewater vessel grouping and representative vessel group selection, see the *Vessel Grouping and Representative Vessel Selection for Surface Vessel Bilgewater/Oil-Water Separator Discharge* (Navy and EPA, 2001a).

# 0.0 OVERVIEW OF DISCHARGE ANALYSES

## 0.0 INTRODUCTION

Technical analyses developed for the UNDS program are divided into three general areas: characterization, environmental effects, and feasibility. The discharge analyses began after potential MPCDs were identified and the vessels that produce the discharge were grouped. Characterization of the discharge was performed to support the subsequent environmental effects and feasibility analyses. The discharge characterization for each vessel group for each MPCD option and the baseline discharge is referred to as the "discharge profile."

The three primary treatment MPCD options (gravity coalescence, hydrocyclone, and centrifuge) that were subject to full analysis for this discharge can each be combined with one of the two secondary treatments that passed MPCD screening (filter media and membrane filtration). As noted in the Bilgewater ChAR (Navy and EPA, 2003a), the gravity coalescence, hydrocyclone, and centrifuge options are assumed to have sufficiently similar oil-water and particulate separating performance potential to allow all three OWS options to be represented by gravity coalescence (Navy and EPA, 2003c). Therefore, the characterization and environmental effects analyses address only:

- Primary treatment (as represented by existing gravity coalescence equipment).
- Primary treatment plus filter media.
- Primary treatment plus membrane filtration.
- Collection, holding, and transfer (CHT).

It is important to note that the baseline discharge profile for each vessel group (i.e., untreated bilgewater) was intended for comparison purposes only. Armed Forces vessels do not discharge untreated bilgewater directly overboard.

### 0.0.0 Potential Marine Pollution Control Device Options

The process to determine the achievable performance levels of discharge treatment for each vessel group (which later would be used to drive performance standards) resulted in the identification of 15 candidate technologies, referred to as MPCD option groups. Summary information is provided below for each of these options. This section also provides a table summarizing the screening results and pass/fail determination rationale. MPCD options that passed screening, as described in the MPCD Screening Guidance Document (Navy and EPA, 2000b), were subject to subsequent environmental and feasibility analyses.

The MPCDs listed below include primary (e.g., gravity coalescence) and secondary treatment options. Secondary MPCDs are treatment options that are used in addition to primary MPCDs to further enhance discharge water quality. These options (e.g., filter media and membrane filtration) are installed in series with primary options to form a treatment train configuration.

#### *0.0.0.0 Centrifuge*

A centrifuge is a mechanical separating device that consists of a bowl or cylinder rotating at high speeds, generating a centrifugal force. In a disk-type separator, centrifugal force is exerted on the waste stream to be processed (process fluid). The force imposed on the process fluid by the centrifuge causes the immiscible liquids (and/or solids) to separate. Typically, disk-type centrifuges are used in the marine environment. In a disk-type centrifuge, a stack of disks is encased in a bowl-like rotating container. The process fluid enters the top of the rotating bowl through a regulating tube. The waste stream then passes down the inside of the regulating tube shaft and out the bottom of the stack of disks. As the process fluid fills the bowl containing the disk stack, the fluid is pushed up through the distribution holes in the disks. As the process fluid flows up through the distribution holes in the disks, the revolving bowl creates a high centrifugal force that is imparted upon the process fluid. The centrifugal force causes the dirt, sludge, and heavier immiscible fluids (generally water) to move outward to the periphery of the bowl where it can be drained to a sludge tank. The lighter fluid (e.g., oil) flows from the top of the disk stack to a holding tank.

#### *0.0.0.0 Dissolved Air Flotation*

Dissolved air flotation (DAF) is a physical/chemical clarification process used for the removal of suspended solids and/or insoluble liquids from wastewaters. In a DAF clarifier, the wastewater influent stream is saturated with air under pressure. Just before entering the clarifier tank, the influent is released to atmospheric pressure, and the dissolved air in the influent comes out as extremely fine bubbles. The bubbles attach themselves to the suspended solids/insoluble liquid droplets in the water and rise to the top of the clarifier, carrying with them the solids and other contaminants in the these droplets. Precipitating and coagulating chemicals are added to the waste stream in the DAF clarifier tanks to enhance system effectiveness. When the bubbles/solids/droplets aggregate reaches the surface, a floating blanket of sludge develops. The floating sludge is removed from the surface by mechanical skimming. Sludge is also formed at the bottom of the tank as heavier solids settle to the bottom. A sediment sump, a lower rake arm, or some similar device collects and transfers this sludge. Clarified effluent can be recycled, sent for further treatment, or directly discharged overboard.

#### *0.0.0.0 Evaporation*

Evaporation is the process of changing a solid or liquid into a vapor. In the context of processing bilgewater/OWS effluent, evaporation requires heating the bilgewater until the water, and various other volatiles it contains, undergo a phase change from liquid phase to vapor phase. The primary components of the only known commercial bilgewater evaporation system include an insulated steel tank of approximately 50-gallon capacity with a lid, a thermostat, a flat floor with a drain, an under-floor or immersed heater, an exhaust fan, and vent stack.

#### *0.0.0.0 Ex Situ Biological Treatment*

An *ex situ* biological treatment system uses a process in which the waste stream is pumped into a reaction vessel containing microorganisms which provide waste treatment. These microorganisms digest the organic content of the waste stream. The digestion process converts the organic material into new cell mass, cell by-products, gas, and water. The cell mass forms aggregates, or floc, the density of which is sufficient to separate the flocs from the treated effluent leaving the reaction vessel. Operational parameters such as waste flow rate, air/nutrient additions, and contact time of the biomass are controlled to create the optimum environment for treating a specific waste stream.

#### *0.0.0.0 Flocculation through Electrocoagulation*

Electrocoagulation is a physiochemical operation commonly used for wastewater treatment. This process results in the destabilization and aggregation of smaller particles into larger particles. The resulting larger particles precipitate from solution or become large enough to be filtered out of solution. Electrocoagulation is based on the principle of passing an electrical current through water to induce a chemical reaction, creating dense flocculation precipitates that can be settled or floated. Because the floc (which forms a sludge) is physically and chemically stable, it can be easily separated from the water by a number of secondary separation techniques, including skimming or accumulation in a sludge buffer tank (55-gallon drum). This option group typically requires the addition of iron or aluminum pellets, or the use of sacrificial anodes to facilitate the separation/flocculation process.

#### *0.0.0.0 Flocculation by Separating Agents*

Separating agents are added to a waste stream to facilitate the coagulation/ flocculation process. Coagulation is achieved by a reduction of electrostatic surface forces, and flocculation is achieved by the use of bridging materials to combine smaller particles into larger agglomerates. Although achieved through different means, both coagulation and flocculation are processes where suspended material present in water in a colloidal form are brought together into larger agglomerates. These agglomerates are then removed during wastewater processing by skimming and filtration. This technology can remove metals, phosphates, suspended solids, oil and grease from wastewater.

#### *0.0.0.0 Gravity Coalescence*

Gravity coalescing type OWSs operate on the principle that due to the different specific gravities of oil and water and their immiscibility with each other, the oil will separate from the water and coalesce into a separate fluid layer. Oily wastewater is pumped from the oily waste holding tank through the OWS, which contains coalescing material. Coalescing material is typically polypropylene, an oleophilic polymer that may be in the form of parallel plates or loose packed media. As the oil droplets, entrained in the influent, flow through the OWS, they will come into contact with the coalescing material and adhere to it. As more droplets attach to the polymer, they will come in contact with each other and form larger droplets (coalesce). These droplets will break free from the plates or media and rise to the surface of the OWS tank where they typically collect in an oil tower. The OWS contains sensors that detect the presence of oil in the oil tower and trigger the OWS to automatically pump the collected oil to a waste oil tank. The treated effluent is scanned for oil content by an oil content monitor. If the effluent appears to contain higher than desired oil content, it is returned to the oily waste holding tank for further processing. If the effluent concentration is acceptable, the effluent is discharged overboard.

### *0.0.0.0 Hydrocyclone*

A hydrocyclone (or cyclone separator) is a simple device, consisting of a cylindrical upper section and a conical lower section that utilizes centrifugal forces to separate fluids of differing density. The fluid and the contaminants, coupled with an applied force to pressurize the fluid, drive the entire process. Oily water is pumped under pressure into the top of the hydrocyclone, where it enters the cylinder tangentially, causing a vortex to form. This vortex creates centrifugal force that pushes denser liquids, such as water, outward toward the walls of the conical section. At the same time, a pressure drop occurs in the center of the vortex where the lower density fluid (oil) is drawn. As the vortex moves down the tapered portion of the hydrocyclone, it accelerates, generating very large centrifugal forces (on the order of 1,000 times the force of gravity). The centrifugal force further separates the two phases: forcing the water to the outside walls while the oil flows toward the center of the vortex. The separated oil flows back up through the center of the vortex and out the center of the cylindrical inlet head section, while the water continues to flow down and out the open end of the conical tail section. The oil stream is directed to a waste oil collection tank. The processed water may be discharged overboard if below regulatory standards or directed to a secondary treatment device for additional processing.

### *0.0.0.0 In Situ Biological Treatment*

Biological treatment works by bringing bacteria into contact with organic compounds, an electron acceptor, and other necessary nutrients for microbial growth. Once in contact, the microbes break down and consume the organic waste, converting it into either gas, water, cell by-products, or microbial cell mass. *In situ* biological treatments are systems in which microbes are introduced directly into a waste stream, such as bilgewater, and allowed to react with its constituents. *In situ* biological treatment is a relatively uncontrolled process since the only controllable parameter is the amount of microbes added to the contaminated area.

### *0.0.0.0 Oil Absorbing Socks*

Oil-absorbing socks (OAS) utilize both oil absorbent and water repellent properties of meltblown (not woven) polypropylene fibers to absorb liquid hydrocarbons from oily wastewater. Meltblown polypropylene fibers have inherent hydrophobic properties and are designed to absorb oil and repel water when placed on (or in) oil water mixtures (i.e., vessel or small boat bilges) (Oil Dri Corp, 2000).

### *0.0.0.0 Supercritical Water Oxidation*

This potential MPCD option involves using a supercritical water oxidation (SCWO) unit to control aqueous organic materials by converting them to carbon dioxide and water. The SCWO unit destroys the aqueous organic matter using the properties of water at supercritical conditions.

### *0.0.0.0 Collection Holding and Transfer (CHT)*

CHT involves the on-board collection, containment, and subsequent transfer of bilgewater to shore facilities or ship waste offload barges (SWOBs). CHT does not involve any treatment of raw bilgewater on-board the generating vessel. CHT may require the installation of some shipboard equipment, such as piping or tanks, to provide additional holding capacity.

#### *0.0.0.0 Filter Media*

Filter media are substances that selectively remove constituents (e.g., organics and metals) from a wastewater. The media have an affinity for a particular suite of constituents. When allowed to come into contact, the constituent is bound to the filter media, typically through adsorption and/or absorption. The types of media studied for this MPCD option group include activated carbon, polypropylene, resin bonded glass fiber, cellulose, humic acid, and synthetic polymers.

#### *0.0.0.0 Membrane Filtration*

Semi-permeable membranes are filtration systems that allow the passage of water, ions, or small molecules, but prohibit the passage of larger molecules (e.g., oil). Membrane filtration devices separate high molecular weight constituents from fluids by forcing the fluid through very small pores of a polymeric or inorganic membrane. The membrane filtration MPCD option group consists of various types of membranes including reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). Membrane filtration systems in use by Armed Forces vessels use UF units designed to remove oil to meet performance levels.

### 0.0.0 MPCD Screening Results

The following table summarizes the screen conclusions and associated rationale for each MPCD option group.

**Table 0-1. Bilgewater MPCD Option Group Screening Summary**

| Option Group | Pass/Fail Rationale |
|---|---|
| **Centrifuge** | **PASS:** Centrifuges have been successfully used aboard Armed Forces surface vessels and commercial vessels for treating surface vessel bilgewater. |
| **Dissolved Air Filtration** | **FAIL:** DAF technology has been used successfully for land-based wastewater treatment applications. However, there are no DAF clarifiers in use on-board waterborne vessels, nor is DAF available commercially for application in the marine environment. |
| **Evaporation** | **PASS:** Although not widely used, this MPCD has been used to treat bilgewater on some commercial inland watercraft. These craft range in size from 100 to 250 feet and generate bilgewater at a rate of less than 50 gallons per day. |
| ***Ex Situ* Biological Treatment** | **FAIL:** *Ex situ* biological treatment devices are currently the subjects of private and public sector research. At this time, there are no existing data to demonstrate that this MPCD is sufficiently proven to treat surface vessel bilgewater on waterborne vessels. |
| **Filter Media** | **PASS:** Filter media has been successfully used aboard Armed Forces surface vessels to treat surface vessel bilgewater. |
| **Flocculation through Electrocoagulation** | **FAIL:** Flocculation through electrocoagulation has been used for many shoreside wastewater treatment applications and is reportedly capable of treating complex waste streams, including bilgewater. However, to date, this technology has not been used to treat surface vessel bilgewater on waterborne vessels. |

| Option Group | Pass/Fail Rationale |
|---|---|
| **Flocculation by Separating Agents** | **FAIL:** Flocculation by separating agents has been used for many shoreside wastewater treatment applications. However, to date, this technology has not been used to treat surface vessel bilgewater on waterborne vessels. |
| **Gravity Coalescence** | **PASS:** Gravity coalescers have been used successfully aboard Armed Forces surface vessels to treat surface vessel bilgewater. |
| **Hydrocyclone** | **PASS:** Hydrocyclones have been successfully used aboard Canadian Navy surface vessels to treat surface vessel bilgewater. |
| ***In Situ* Biological Treatment** | **PASS:** *In situ* devices have demonstrated the ability to degrade oil in the bilgewater of recreational boats and USCG cutters. However, the rate at which the degradation occurs and the relative effectiveness has not been quantified fully. *In situ* biological treatment is a process that has not been proven to consistently produce an effluent with oil content suitable for overboard discharge. |
| **Membrane Filtration** | **PASS:** Membrane filtration is successfully used on-board Armed Forces surface vessels to treat surface vessel bilgewater. |
| **Oil Absorbing Socks** | **PASS:** OASs are successfully used in bilge areas on small recreational boats to prevent oil from being released during unintentional bilgewater discharges. |
| **Supercritical Water Oxidation** | **FAIL:** SCWO technology is available for commercial use (Freeman, 1989), but has not been used on a waterborne vessel or in the marine environment to treat surface vessel bilgewater. |
| **CHT** | **PASS:** Armed Forces vessels successfully practice CHT. |

## 0.0.0 Characterization

Characterization information collected on surface vessel bilgewater is organized among the following topics: physical parameters, chemical data, field testing, descriptive information, and discharge generation rates.

### *0.0.0.0 Physical Parameters*

Characterization of the physical parameters of the discharge refers to the information gathered on how the discharge is released to the environment. This information is needed to support dilution modeling as part of the EEA (described in Section 3.1.5). This information includes vessel dimensions, discharge port measurements, flow rate and duration, and discharge density (determined by salinity values). The primary sources of these data are technical literature reviews and the engineering information gathered on the representative vessel, particularly ship drawings and equipment specifications.

### *0.0.0.0 Chemical Data*

To support the requirements of the EEA, potentially toxic constituents of the discharge were identified and quantified (by concentration). The primary source of this information was sample analysis. In Phase I, sampling was performed on USS JOHN C. STENNIS (CVN 74). Additional sampling was performed for Phase II on USS MAHAN (DDG 72), USS OAK HILL (LSD 51), USCGC MORGENTHAU (WHEC 722), USS DAVID R. RAY (DD 971), USS BONHOMME RICHARD (LHD 6), USS CARNEY (DDG 64), and USS RUSHMORE (LSD 47). The selection of analytes and analysis methods are detailed in the Specified Sampling and Analysis Plans (SSAPs), which are listed in the Reference section.

Process knowledge was used to develop discharge profiles for instances where sampling was not practical (e.g., the evaluation of MPCD options on vessels which do not have the option installed). In these cases, constituent concentrations were estimated using empirical formulas developed by Putnam and Singerman (2001). Specifically, secondary treatment profiles (i.e., those used as part of a treatment train) were developed by applying these formulas to primary treatment results. In other cases, baseline and primary treatment results were derived from surrogate data and supplemented by process knowledge from equipment experts and vessel drawings. In particular, due to similarities in machinery, propulsion systems, and ancillary equipment, the LSD 41 vessel group discharge information is used to represent the MCM and WPB vessel groups.

#### *0.0.0.0 Field Testing*

Field testing was performed to obtain values for parameters that can not be measured in preserved samples. Parameters measured in the field included pH, temperature, salinity, specific conductance, and total- and free-chlorine. Additional characterization information on colloidal matter, color, floating materials, nuisance species, odor, settleable materials, total dissolved gases, transparency, and turbidity were collected for narrative water quality criteria (WQC) evaluations as part of the EEA.

#### *0.0.0.0 Descriptive Information*

Descriptive information on the discharge was also required to compare discharge characteristics to narrative criteria endpoints. This information was generally collected through observation of discharge samples. Categories of narrative criteria directly related to descriptive information include color, floating materials, odor, settleable materials, and turbidity/colloidal matter.

#### *0.0.0.0 Discharge Generation Rates*

A determination of annual discharge generation rates was necessary to support feasibility and environmental effects analyses. The determination of discharge generation volume was *not* made by using a selected vessel class to represent each vessel group. Instead, generation rates were determined for each vessel class that produces the discharge. Information on the discharge-processing rate (i.e., the rate that bilgewater is pumped out when sent through the OWS) was assembled, along with the number of hulls within a class and vessel movement data, to calculate the annual discharge volumes. Vessel movement data include details regarding the time each representative vessel spends in fresh and saltwater and the number of days spent in port vice operating within and outside of 12 nm.

Data quality was considered for all analyses conducted. To ensure adequate data quality, after reviewing documented matrix spike failures and process information discrepancies, a confirmation analysis was conducted for pesticides. This confirmation analysis revealed that there were no pesticides present in the reanalyzed samples. As a result, pesticides are not included in bilgewater discharge profiles (Navy and EPA, 2003d).

Constituent concentrations and other characterization data for each discharge profile are located in the Bilgewater ChAR appendices (Navy and EPA, 2003a).

### 0.0.0 Feasibility

The feasibility analysis is organized by vessel group and analyzes criteria for each MPCD option group relative to each representative vessel. Feasibility criteria were considered for both existing vessels and new design vessels, and for each MPCD option group that passed the MPCD screening process. MPCD option groups can be management plans, practices, alternative materials, or control devices. The specific criteria considered in the feasibility analyses are detailed in the Feasibility Impact Analysis Guidance Document (Navy and EPA, 2000c).

Feasibility information used in this report belongs to either of two general categories: 1) general data developed for the UNDS program that are subject to uncertainty analysis and the rules of significant figures, and 2) information collected from other sources (e.g., vendor claims) that are treated as constants for calculation purposes. The Navy's Alteration and Installation Team (AIT) and Total Ship System Directorate of the Naval Surface Warfare Center, Carderock Division, (NSWCCD Code 20) supported the development of these analyses. Their estimates and conclusions are referenced throughout this report.

Within each personnel impact section, the maintenance activities for each MPCD are presented as either time-based or condition-based. Time-based maintenance includes those activities performed according to a preset calendar schedule (e.g., annual, semi-annual, quarterly) and is independent of the number of hours the MPCD is operated. Condition-based maintenance includes all maintenance activities that are dependent upon the number of hours the MPCD is operated (e.g., every 500 hours). Hours of MPCD operation were estimated based on the amount of time it takes to process the volume of bilgewater generated annually.

#### *0.0.0.0 Economic Cost Analysis*

Cost analyses developed herein are for purposes of MPCD comparison as part of performance standard development in Phase II of UNDS. The following cost analyses are not intended for preparation of actual implementation costs. To the extent possible, the analyses divide cost estimates between vessel operations within 12 nm of shore and vessel operations beyond 12 nm.

Economic costs were estimated using Automated Cost Estimating Integrated Tool (ACEIT) software. ACEIT software is widely used within the DoD cost analysis community (ACEIT, 1999). All costs are presented in 1999 dollars. Summary tables that present how costs were converted to 1999 dollars are shown in the Bilgewater FIAR Appendix A. Cost data for individual initial and recurring cost items that were obtained subsequent to fiscal year 1999 were converted to 1999 dollars using the Consumer Price Index (CPI). The CPI is a general inflation rate published by the Bureau of Labor Statistics. More specialized inflation rates exist for specific costs (e.g., labor rates, machinery procurement cost, oily wastewater disposal cost); however, because costs were adjusted over a very short time period, using specialized inflation rates would not significantly affect the outcome of the calculations.

### *Initial Cost*

The initial cost estimates developed for each MPCD option group include acquisition, installation, and technical data (e.g., manuals, drawings, training guides) development costs. The estimated initial costs are the incremental costs, or additional costs, to install the MPCD. If the MPCD is already installed, there are no incremental costs. Acquisition costs indicate the total cost to purchase the number of MPCDs required to achieve the designated processing rate per representative vessel. Acquisition costs were provided by vendors or equipment experts with acquisition cost knowledge. These costs may vary between manufacturers; however, that difference is not expected to be significant. The development of acquisition, installation, and technical data development cost estimates required the use of assumptions based upon Navy experience.

### *Recurring Cost*

The recurring costs considered in the feasibility analyses include labor costs for operating and maintenance, consumable costs, and waste material disposal costs. These individual costs, associated assumptions, and calculations are reported in the respective Personnel Impact sections. The recurring costs are incurred on an annual basis. The individual recurring cost items are described under the recurring cost sections and totaled under the Total Ownership Costs (TOC) sections. The annual labor cost was estimated by adding the personnel labor requirement for operating equipment and transferring waste oil to shore to the routine maintenance labor requirement.

### *Total Ownership Costs*

The TOC is a sum of the total initial and the total recurring costs. The ACEIT model estimated the TOC of each MPCD option group over a 15-year lifecycle. This model assumes that acquisition and installation occur during year one of the 15-year lifecycle, and MPCD operation begins the following year. Therefore, the first year reflects initial costs only, and years two through 15 reflect recurring costs only. The ACEIT model presents the cost-estimate results as total initial, total recurring, and overall total cost expressed in 1999 dollars. ACEIT discounted future costs (i.e., recurring cost) using a discounted cash flow methodology to account for the time value of money. The cost analysis used a discount rate of 3.2% that was based on the real interest rates on 15-year Treasury Notes and Bonds (OMB, 1992).

### *Annualized Cost*

Annualized costs were calculated using standard annualization methods. This process facilitated the cost analysis by representing each year in the 15-year life cycle by a single value. Annualized costs are presented for comparing costs of MPCD option groups.

### *0.0.0.0 New Design Vessels*

Vessels in the design stage ("new design vessels") are vessels authorized by Congress and for which the Department of Defense or the Coast Guard has established a program office to oversee their design. Assessments reported in the FIAR were developed using the assumption that new design vessels will have similar discharge characteristics (e.g., bilgewater constituent composition) as a representative existing vessel and will have additional flexibility as compared to existing vessels.

New design analyses parallel existing representative vessel classes and follow new design analysis guidelines (Navy and EPA, 2002a). A new design vessel's ability to collect bilgewater may also be improved by designing systems that reduce the amount of bilgewater generated. As discussed in Shipboard Compliance and Pollution Prevention Program (Navy and EPA, 2002b), the Navy is implementing several pollution prevention initiatives to reduce bilgewater generation volumes. These include incorporating non-oily machinery wastewater collection systems, or "dry bilge", into the ship design, installing mechanical seals on pumps, and developing improved shaft seals.

MPCD feasibility for new design vessels was analyzed using existing vessels as a baseline, as described below:

- At a minimum, new design vessels were assumed to be able to accommodate MPCDs that are in-place or were determined to be viable for installation on corresponding existing vessels. Therefore, these “in-place” MPCDs were not analyzed for new design vessels because the discharges were expected to have similar characteristics as those on existing vessels.

- Only MPCDs that could provide an additional environmental benefit over the in-place MPCDs were analyzed.

- Professional judgment was used to compare the feasibility (i.e., practicability, economic costs, and operational impacts) of installing and using an MPCD on a new design vessel to that of an in-place MPCD. Installation cost for an MPCD aboard a new design vessel was assumed to be 67% of the cost for retrofitting the device aboard an existing vessel (Navy and EPA, 2002a).

### 0.0.0 Environmental Effects Analysis

UNDS program managers designed the environmental effects analysis of discharges to have two components. The first component is the analysis of immediate impacts from vessel discharges. That analysis included an evaluation of the acute toxicity to aquatic life, an identification of bioaccumulators, and an evaluation of other environmental impacts (e.g., nutrient loading, pathogen inputs, and thermal effects). The second component of the environmental effects analysis, the cumulative impact analysis (CIA), is intended to consider environmental impacts that arise due to multiple discharges from multiple vessels and to evaluate certain environmental impacts not addressed in the EEA, which are more complex than simple toxicological effects.

The EEA of bilgewater impacts presented in this report are in accordance with the methodology contained in the EEA guidance manual (Navy and EPA, 2000a), with a few exceptions wherein a streamlined analysis was determined to be suitable (presented in Section 3.2). In these cases, collection of the entire discharge within 12 nm of shore was determined to be a feasible option.

As a result, there is no discharge to the receiving waters inside 12 nm and the need for further characterization or environmental effects analysis was considered to be superfluous.

In short, the analysis has several steps. After the discharge has been characterized (as described in the previous section), constituent concentrations are compared to a collection of State water quality standards and Federal guidance values. Bioaccumulative contaminants of concern (BCCs) are identified in the discharge based on lists of elimination and reduction BCCs provided by EPA and other sources. Mass loading calculations, along with toxic weighting factors (TWFs) provided by EPA, are used to derive toxic pounds equivalents (TPEs) that allow for cumulative toxic loading to be estimated.

Net acute aquatic-life toxicity is estimated using a hazard index (HI) approach. End-of-pipe (EOP) and edge of a mixing zone (EOMZ) constituent concentration values are divided by toxicological endpoint concentrations (TECs). The constituent-specific result of these calculations is the hazard quotient (HQ); the summation is the HI. An HI of 1.0 or less is the level considered to be protective of aquatic life from acute toxic effects of the discharge. This level is equivalent to the EPA WQC for aquatic life [i.e., Criterion Maximum Concentration (CMC)]. The CMC is intended to protect most species most of the time (EPA, 1991). This level of protection is set near the concentration resulting in no observable effect on the most sensitive aquatic species, which EPA has determined will adequately protect aquatic communities.

As discussed in the EEA guidance manual (Navy and EPA, 2000a), the mixing zone used by the UNDS program is the volume of water within a distance 35m from the discharge point. The dilution at EOMZ is an important variable in the determination of the environmental impact a discharge has on the receiving waters. The analysis of bilgewater followed the pierside modeling approach described in the Technical Approach for Pierside Modeling to Support UNDS EEA Phase II (Navy and EPA, 2001b).

The EEA process also assesses the potential for non-indigenous species (NIS) transport and other environmental considerations unique to the discharge (e.g., impacts to air quality). In the case of bilgewater, the potential for the baseline discharge to introduce NIS is expected to be low because "there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances" (EPA and DoD, 1999). The other potential environmental concern identified for this discharge is due to the indirect impacts to the environment that could occur as a result of shoreside treatment. Offloaded bilgewater is treated at properly-permitted facilities and is subject to applicable Federal, State, and local disposal regulations.

Discharge profiles were not created for every combination of MPCD option and vessel group. In some cases, MPCDs were eliminated from evaluation as a result of the feasibility analysis (see the Bilgewater FIAR).

## 0.0 VESSEL GROUPS SUBJECT TO STREAMLINED ANALYSIS

For five of the 13 vessel groups, collection of the entire discharge within 12 nm of shore was determined to be a feasible option. The use of this option results in no direct discharge to the receiving waters; therefore, the need for formal characterization or environmental effects analysis was considered to be superfluous. The five vessel groups include:

- Non-operational vessels: LKA 113.
- Compression ignition (CI) boats under 65 ft: UTB 41.
- Spark ignition (SI) inboard vessels: QST 35.
- SI outboard vessels: CB-M.
- Non-powered vessels: YC 1607.

Further information on the feasibility analysis of these vessel groups can be found in their respective chapters in the Bilgewater FIAR (Navy and EPA, 2003b).

## 0.0 NUCLEAR STEAM PROPULSTION VESSELS (CVN 68)

The only nuclear-powered surface vessels in service with the Armed Forces are the Navy aircraft carriers ENTERPRISE (CVN 65) and NIMITZ (CVN 68) Classes. The CVN 65 is a class with only one vessel, while the CVN 68 Class has 10 vessels. These vessels measure over 1,000 ft in length, displace more than 70,000 tons (Polmar, 1997), and operate outside 12 nm from shore except when transiting to and from port. These vessels have nuclear reactors that supply heat to steam generators. The steam from the generators drives the main propulsion turbines. The steam generators require blowdowns, however the resulting wastewater is not directed to the bilge.

### 0.0.0 CVN 68 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included engineering data on ship systems and details regarding discharge composition.

During UNDS Phase I, sampling was conducted aboard one vessel of the CVN 68 Class, USS JOHN C. STENNIS (CVN 74), from 5 March 1997 to 7 March 1997 to supplement process knowledge on the composition of the discharge. This sampling episode serves as the primary source of chemical data, as well as field and descriptive data, for this vessel group. The samples were analyzed by ETS Analytical Services and Pacific Analytical, Inc. The subsequent results were reviewed by the EPA and DoD to determine the quality of the analytical data; however, some sample data were excluded in the final calculations, as documented in the *Sampling Episode Report - Volume II -USS JOHN C. STENNIS* (Navy, 1998) based upon Sample Control Center (SCC) review. As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

The characterization of the bilgewater discharge after secondary treatment by filter media could not be performed based on sample analysis because this operation is not in everyday practice aboard this vessel class. Discharge composition properties were estimated using Putnam and Singerman (2001) calculations as well as comparisons to the performance achieved by filter media on DDG 51 Class vessels. Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 0.0.0 CVN 68 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-2.

**Table 3-2. CVN 68 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD* (Gravity Coalescer) | 163 $ft^3$ 4,800 lbs. (dry) 9,000 lbs (flooded) No impact – current MPCD | No impact | No impact | 245 hrs | 386 hrs | None | Electrical power—440VAC, 60Hz Potable water—needed as a primer Sea water—25 psi Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 766 $ft^3$ 6,300 lbs (dry) 7,000 lbs (flooded) Existing OWS would be removed and replaced with unit | No impact | No impact | 113 hrs | 386 hrs | Minimal consumables required. Special tools available from vendor | Electrical power—440VAC, 80-130kW Compressed Air--0.0045-0.022 cfm @ 50 psig Potable water—50 gpd, 45 psi Gravity drain | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity; can support an approximate 6 hours of transit time | No impact | No impact | 750 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after two days | Significant impact after two days | Significant impact after two days | Significant impact after two days | NA | None | None | None | None |
| Evaporation | NF – excessive power requirements | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Hydrocyclone | 168 $ft^3$<br>900 lbs (dry)<br>1,000 lbs (flooded)<br>Existing OWSs would be removed | No impact | No impact | 79 hrs | 386 hrs | Consumables and repair parts (e.g., "O" rings, gaskets for cyclone vessel, cyclone liners, and pump components) required | Electrical power—460VAC, 60 Hz | Automated control panel, tank level switches, can be equipped with OCM | None |
| *In Situ* Biological Treatment | NF – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | NF – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | 87 $ft^3$<br>3,650 lbs (dry)<br>8,375 lbs (flooded)<br>Existing workbench and storage locker may have to be removed; deballasting tanks and piping may have to be relocated. | No impact | No impact | 11 hrs | NA | Requires replacement of filter media canisters | None | Automated operation in response to primary OWS | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |
| Membrane Filtration | 440 $ft^3$<br>9,200 lbs (dry)<br>12,000 lbs (flooded)<br>Significant impacts on older vessels; extent of impacts on other vessels will vary | No impact | No impact | 42 hrs | NA | Requires replacement of membranes (performed shoreside) | Electrical power—440VAC, 60 HZ<br>Compressed Air – 5 scfm at 80 to 100 psi<br>Potable water – 10 gpm at 30 psi<br>Gravity drain | Automated operation in response to primary OWS | None |

**Table 3-3. CVN 68 MPCD Total Ownership Cost Comparison ($K/vessel)**

| MPCD Option | Total Initial Inside 12 nm/ Inside+Beyond 12 nm | Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Annualized Inside 12 nm/ Inside+Beyond 12 nm | Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 62/180 | 5.3/15.3 | 62/180 |
| Centrifuge | 1170/1170 | 28.4/97 | 102/108 | 1200/1270 |
| CHT (within current holding capacity) | 0/0 | 2440/2440 | 207/207 | 2440/2440 |
| Hydrocyclone | 224/224 | 20/91.4 | 20.7/27.3 | 244/321 |
| Filter Media | 208/208 | 869/869 | 91.5/91.5 | 1080/1080 |
| Membrane Filtration | 968/968 | 11/11 | 83.2/83.2 | 979/979 |

## 0.0.0 CVN 68 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-4 and Table 3-5.

**Table 3-4. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Cadmium | 5.0E+00 | 5.4E+00 | 5.1E+00 | 5.1E+00 | 1.0E+00[3] | 0 |
| Copper | 2.4E+00 | 2.6E+02 | 1.6E+02 | 1.6E+02 | 1.6E+02 | 0 |
| Iron | 3.0E+02 | 5.2E+02 | 4.7E+02 | 1.9E+02[3] | 9.4E+01[3] | 0 |
| Mercury | 2.5E-02 | 9.2E-02 | 5.2E-02 | 5.2E-02 | 5.2E-02 | 0 |
| Nickel | 8.3E+00 | 3.0E+02 | 1.7E+02 | 1.3E+02 | 1.8E+02 | 0 |
| Selenium | 1.0E+00 | 1.2E+01 | ND | ND | ND | 0 |
| Zinc | 5.0E+01 | 1.6E+03 | 8.8E+02 | 5.3E+02 | 8.6E+02 | 0 |
| Number of Constituents exceeding strictest WQC | - | **7** | **6** | **5** | **4** | **0** |
| **Total Exceeded Numeric Criteria** | **-** | **78** | **77** | **76** | **74** | **0** |

*[1] Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

*[2] CHT does not release constituents to the receiving waters*

*[3] This concentration does not exceed water quality criteria.*

*ND = Not Detected*

**Table 3-5. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)**

<table>
<tr><th>Discharge Constituent</th><th>Baseline</th><th>Primary Treatment</th><th>Primary Treatment Plus Filter Media[1]</th><th>Primary Treatment Plus Membrane Filtration[1]</th><th>CHT[2]</th></tr>
<tr><td>Bis (2-Ethylhexyl) Phthalate</td><td>5.5E+00</td><td rowspan="2">ND</td><td rowspan="2">ND</td><td rowspan="2">ND</td><td rowspan="2">0</td></tr>
<tr><td>TPE:</td><td>[3]</td></tr>
<tr><td>Cadmium</td><td>1.3E+00</td><td>1.3E+00</td><td>1.3E+00</td><td>2.5E-01</td><td rowspan="2">0</td></tr>
<tr><td>TPE:</td><td>8.8E-01</td><td>8.4E-01</td><td>8.4E-01</td><td>1.7E-01</td></tr>
<tr><td>Copper</td><td>1.4E+02</td><td>8.4E+01</td><td>4.2E+01</td><td>4.8E+01</td><td rowspan="2">0</td></tr>
<tr><td>TPE:</td><td>2.5E+02</td><td>1.5E+02</td><td>7.6E+01</td><td>8.8E+01</td></tr>
<tr><td>Iron</td><td>1.3E+02</td><td>1.1E+02</td><td rowspan="2">ND</td><td rowspan="2">ND</td><td rowspan="2">0</td></tr>
<tr><td>TPE:</td><td>2.2E+-01</td><td>1.9E-01</td></tr>
</table>

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Mercury | 2.2E-02 | 1.3E-02 | 1.3E-02 | 1.3E-02 | 0 |
| *TPE:* | *2.6E+00* | *1.5E+00* | *1.5E+00* | *1.5E+00* | |
| Nickel | 7.4E+01 | 4.1E+01 | 3.1E+01 | 4.3E+01 | 0 |
| *TPE:* | *5.1E+01* | *2.8E+01* | *2.1E+01* | *2.9E+01* | |
| Nitrate/Nitrite | 1.3E+02 | 6.6E+01 | 4.0E+01 | 6.6E+01 | 0 |
| *TPE:* | *1.2E+01* | *6.1E+00* | *3.7E+00* | *6.1E+00* | |
| Oil and Grease (HEM[4]) | 1.3E+04 | 5.7E+03 | 1.7E+03 | 2.1E+03 | 0 |
| *TPE:* | | | | | |
| Selenium | 2.8E+00 | ND | ND | ND | 0 |
| *TPE:* | *2.3E-01* | | | | |
| Sulfate | 1.2E+05 | 2.2E+05 | 2.2E+05 | 2.2E+05 | 0 |
| *TPE:* | *6.7E-01* | *1.2E+00* | *1.2E+00* | *1.2E+00* | |
| Total Sulfide | 2.0E+03 | 1.2E+03 | 2.5E+02 | ND | 0 |
| *TPE:* | *5.7E+03* | *3.4E+03* | *6.9E+02* | | |
| Zinc | 4.0E+02 | 2.1E+02 | 1.3E+02 | 2.1E+02 | 0 |
| *TPE:* | *2.8E+01* | *1.5E+01* | *8.9E+00* | *1.5E+01* | |
| **Total TPE Load** | **6.1E+03** | **3.7E+03** | **8.8E+02** | **2.1E+02** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-6. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)**

| | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 7 | 6 | 5 | 4 | 0 |
| Total Number of Exceeded Numeric WQC | 78 | 77 | 76 | 74 | 0 |
| Number of Exceeded Narrative Categories | 5 | 5 | 3 | 3 | 0 |
| Discharge HI at EOMZ | 7.8E+01 | 4.7E+01 | 1.6E+01 | 1.1E+01 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 6 | 4 | 4 | 4 | 0 |
| Discharge TPE | 6.1E+03 | 3.7E+03 | 8.8E+02 | 2.1E+02 | 0 |

[1] *Constituent concentrations were calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is equal or superior, for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Given the uncertainty associated with sample data, the environmental effects analysis could only distinguish between the two secondary treatment options by TPE ranking. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 CVN 68 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-7.

**Table 3-7. TPEs Removed for each MCPD option and Associated Costs (CVN 68)**

| Parameter (values per vessel group) | Filter Media | Membrane Filtration | CHT |
|---|---|---|---|
| TPE removed from primary discharge by listed treatment | 2.80E+03 | 3.49E+03 | 3.90E+03 |
| Cost per TPE removed over primary treatment for existing vessels ($/yr) | $359 | $262 | $584 |
| Cost per TPE removed after replacing existing group of vessels with new design vessels ($/yr) | $329 | $204 | $519 |
| Cost per pound of oil removed over primary treatment for existing vessels ($/yr) | $526 | $410 | $620 |
| Cost per pound of oil removed after replacing existing group of vessels with new design vessels ($/yr) | $480 | $320 | $509 |

## 0.0 CONVENTIONAL STEAM POWERED VESSELS (LHD 1)

This group consists of 62 vessels distributed among 19 vessel classes. Vessels in this group include three aircraft carriers, various large amphibious ships, auxiliaries, and Military Sealift Command (MSC) ships. These large ships range from 520 ft to over 1000 ft in length and from 8,200 to over 60,000 displacement tons. These vessels use from two to eight boilers to generate steam for propulsion power, with approximately 72 % of the vessels using two boilers. These vessels operate outside 12 nm from shore except when on training exercises or transiting to and from port. Required daily boiler blowdowns result in larger volumes of bilgewater than in comparably sized ships powered by nuclear, gas turbine, or compression ignition engines.

### 3.4.1 LHD 1 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

During Phase II, sampling was conducted aboard one vessel of the LHD 1 Class, USS BONHOMME RICHARD (LHD 6), on 16-17 December 1999. This sampling episode serves as the primary source of chemical data for this vessel group. The samples were analyzed by Columbia Analytical, Ecology and Environment, Pacific Analytical, and Q Biochem laboratories. The results were reviewed by EPA and DoD to determine the quality of the analytical data. Some sample data were excluded in the final calculations, as documented in the *Draft Uniform National Discharge Standards Surface Vessel Bilgewater/ Oil-Water Separator (OWS) Discharge Sampling Episode Report -USS BONHOMME RICHARD* (LHD 6) (Navy, 2000a), based upon Sample Control Center (SCC) review. As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

The characterization of the bilgewater discharge after secondary treatment could not be performed based on sample analysis because this operation is not in everyday practice aboard this vessel class. Discharge composition properties were estimated using Putnam and Singerman (2001) calculations as well as comparisons to the performance achieved by secondary treatment technology on other vessels. Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.4.2 LHD 1 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-8.

**Table 3-8. LHD 1 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD * (Gravity Coalescer) | 162 $ft^3$ 4,800 lbs. (dry) 9,000 lbs (flooded) No impact | No impact | No impact | 212 hrs | 132 hrs | None | Electrical power—440VAC, 60Hz Potable water—primer, 25 psi max Sea water— 25 psi Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 787 $ft^3$ 6,300 lbs (dry) 7,000 lbs (flooded) Existing OWS would be removed and replaced with unit | No impact | No impact | 81 hrs | 132 hrs | Minimal consumables required; special tools required, but included in the initial purchase | Electrical power—440VAC Compressed Air – 0.0058-0.029 scfm @ 50 psig Potable water—50 gpd, 45 psi Gravity drain Seawater- 25 psi | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 710 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after one day | Significant impact after one day | Significant impact after one day | Significant impact after one day | NA | None | None | None | None |
| Evaporation | **NF** – excessive power requirements | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Hydrocyclone | 168 $ft^3$<br>900 lbs (dry)<br>1,000 lbs (flooded)<br>OWSs may have to be removed and replaced with a single unit. | No impact | No impact | 46 hrs | 132 hrs | Minimal consumables and repair parts required | Electrical power—460VAC, 60 Hz | Automated control panel, tank level switches; can be equipped with OCM | None |
| *In Situ* Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | 85 $ft^3$<br>3,650 lbs (dry)<br>8,375 lbs (flooded)<br>Existing workbench and storage locker may have to be removed; deballasting tanks and piping may have to be relocated. | No impact | No impact | 5.3 hrs | NA | Requires replacement of filter media canisters | None | Automated operation in response to primary OWS | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Membrane Filtration | 441 $ft^3$<br>9,200 lbs (dry)<br>12,000 lbs (flooded)<br>Significant impacts on older vessels; extent of impacts on other vessels will vary | No impact | No impact | 28 hrs | NA | Requires replacement of membranes (performed shoreside) | Electrical power—440VAC, 60 HZ<br>Compressed Air – 5 scfm at 80 to 100 psi<br>Potable water – 10 gpm at 30 psi<br>Gravity drain | Automated operation in response to primary OWS | None |

**Table 3-9. LHD 1 MPCD Total Ownership Cost Comparison ($K/vessel)**

| MPCD Option | Initial Inside 12 nm/ Inside+Beyond 12 nm | 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Annualized Inside 12 nm/ Inside+Beyond 12 nm | Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 53.5/86.7 | 4.5/7.4 | 53.5/86.7 |
| Centrifuge | 1161/1161 | 20/53 | 100/103 | 1181/1214 |
| CHT (within current holding capacity) | 0/0 | 1249/1249 | 106/106 | 1249/1249 |
| Hydrocyclone | 203/203 | 11/44 | 18/21 | 214/247 |
| Filter Media | 245/245 | 412/412 | 56/56 | 660/660 |
| Membrane Filtration | 943/943 | 7/7 | 81/81 | 950/950 |

## 0.0.0 LHD 1 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-10 and Table 3-11.

**Table 3-10. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Vessels with Conventional Steam Propulsion (LHD 1)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| 2,4-Dimethylphenol | 2.7E+02 | 2.5E+02[3] | 5.9E+02 | 2.4E+02[3] | 5.9E+02 | 0 |
| Ammonia as Nitrogen | 2.3E+02 | 5.6E+03 | 5.5E+03 | 5.5E+03 | 5.5E+03 | 0 |
| Bis (2-Ethylhexyl) Phthalate | 4.5E+03 | 1.8E+01[3] | ND | ND | ND | 0 |
| Cadmium | 5.0E+00 | 5.3E+00 | 5.0E+00[3] | 5.0E+00[3] | ND | 0 |
| Copper | 2.4E+00 | 4.0E+01 | 1.3E+01 | 1.3E+01 | 1.3E+01 | 0 |
| Iron | 3.0E+02 | 2.2E+03 | 2.1E+03 | 8.6E+02 | 1.7E+03 | 0 |
| Lead | 5.6E+00 | 1.0E+01 | 1.1E+01 | 1.1E+01 | 4.0E+00[3] | 0 |
| Manganese | 1.0E+02 | 1.3E+02 | 1.2E+02 | 1.2E+02 | 1.2E+02 | 0 |
| Naphthalene | 1.4E+02 | 5.2E+01[3] | 5.2E+01[3] | 2.1E+01[3] | 5.2E+01[3] | 0 |
| Nickel | 8.3E+00 | 5.1E+02 | 4.7E+02 | 3.5E+02 | 3.9E+02 | 0 |
| Selenium | 1.0E+01 | 2.1E+01 | 2.1E+01 | 2.1E+01 | 2.1E+01 | 0 |
| Silver | 1.0E-01 | 6.1E+00 | ND | ND | ND | 0 |
| Thallium | 6.3E+00 | 1.2E+01 | 1.1E+01 | 1.1E+01 | ND | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 1.1E+02 | 9.5E+01 | 9.5E+01 | 9.5E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 5.2E+01 | 5.2E+01 | 2.1E+01 | 5.2E+01 | 0 |
| Zinc | 5.0E+01 | 2.0E+03 | 1.8E+03 | 1.1E+03 | 4.1E+02 | 0 |
| **Number of Constituents exceeding strictest WQC** | - | **13** | **12** | **11** | **10** | **0** |
| **Total Exceeded Numeric Criteria** | - | **87** | **67** | **66** | **65** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters within 12 nm.*

[3] *Does not exceed criteria.*

*ND = Not detected*

**Table 3-11. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (LHD 1)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| 2,4-Dimethylphenol | ND | 4.6E+02 | ND | 4.6E+02 | 0 |
| *TPE:* | | *2.5E+00* | | *2.5E+00* | |
| Ammonia as Nitrogen | 4.3E+03 | 4.2E+03 | 4.2E+03 | 4.2E+03 | 0 |
| *TPE:* | *3.5E+01* | *3.5E+01* | *3.5E+01* | *3.5E+01* | |
| Bis (2-Ethylhexyl) Phthalate | 1.4E+01 | 9.2E+00 | ND | ND | 0 |
| *TPE:* | [3] | [3] | | | |
| Cadmium | 4.0E+00 | 3.8E+00 | 3.8E+00 | ND | 0 |
| *TPE:* | *2.7E+00* | *3.8E+00* | *2.6E+00* | | |
| Copper | 9.7E+02 | 8.7E+02 | 4.3E+02 | 1.8E+02 | 0 |
| *TPE:* | *1.8E+03* | *1.5E+03* | *8.0E+02* | *3.3E+02* | |
| Iron | 1.7E+03 | 1.6E+03 | 6.6E+02 | 1.3E+03 | 0 |
| *TPE:* | *2.9E+00* | *2.7E+00* | *1.1E+00* | *2.3E+00* | |
| Lead | 8.1E+00 | 8.2E+00 | 8.2E+00 | 3.1E+00 | 0 |
| *TPE:* | *5.3E+00* | *5.9E+00* | *5.9E+00* | *2.1E+00* | |
| Manganese | 1.0E+02 | 9.3E+01 | 9.3E+01 | 9.2E+01 | 0 |
| *TPE:* | *6.2E+01* | *5.6E+01* | *5.6E+01* | *5.6E+01* | |
| Naphthalene | 4.0E+01 | 4.0E+01 | 1.6E+01 | 4.0E+01 | 0 |
| *TPE:* | *1.9E+00* | *1.9E+00* | *7.6E-01* | *1.9E+00* | |
| Nickel | 3.9E+02 | 3.6E+02 | 2.7E+02 | 3.0E+02 | 0 |
| *TPE:* | *2.7E+02* | *2.5E+02* | *1.9E+02* | *2.0E+02* | |
| Oil and Grease (HEM[4]) | 4.1E+04 | 2.7E+04 | ND | ND | 0 |
| *TPE:* | | | | | |
| Selenium | 1.6E+01 | 1.6E+01 | 1.6E+01 | 1.6E+01 | 0 |
| *TPE:* | *1.3E+00* | *1.3E+00* | *1.3E+00* | *1.3E+00* | |
| Silver | 4.7E+00 | ND | ND | ND | 0 |
| *TPE:* | *1.4E+02* | | | | |
| Sulfate | 2.9E+05 | 3.3E+05 | 3.3E+05 | 3.3E+05 | 0 |
| *TPE:* | *1.6E+00* | *1.8E+00* | *1.8E+00* | *1.8E+00* | |
| Thallium | 9.1E+00 | 8.3E+00 | 8.3E+00 | ND | 0 |
| *TPE:* | *8.2E+00* | *7.5E+00* | *7.5E+00* | | |
| Total Sulfide | 2.5E+03 | 2.0E+03 | ND | ND | 0 |
| *TPE:* | *6.9E+03* | *5.6E+03* | | | |
| Zinc | 1.5E+03 | 1.4E+03 | 8.4E+02 | 3.2E+02 | 0 |
| *TPE:* | *1.0E+02* | *9.4E+01* | *5.9E+01* | *2.2E+01* | |

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| **Total TPE Load** | **9.4E+03** | **7.8E+03** | **1.3E+03** | **8.0E+02** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-12. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Vessels with Conventional Steam Propulsion (LHD 1)**

| | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 13 | 12 | 11 | 10 | 0 |
| Total Number of Exceeded Numeric WQC | 87 | 67 | 66 | 65 | 0 |
| Number of Exceeded Narrative Categories | 8 | 8 | 2 | 4 | 0 |
| Discharge HI at EOMZ | 6.5E+01 | 5.6E+01 | 1.9E+01 | 1.0E+01 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 7 | 7 | 6 | 5 | 0 |
| Discharge TPE | 9.4E+03 | 7.8E+03 | 1.3E+03 | 8.0E+02 | 0 |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is superior for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 LHD 1 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-13.

**Table 3-13. TPEs Removed for each MPCD Option and Associated Costs (LHD 1)**

| | Filter Media | Membrane Filtration | CHT |
|---|---|---|---|
| TPE removed from primary discharge by listed treatment | 7.60E+03 | 8.00E+03 | 9.40E+03 |
| Cost per TPE removed over primary treatment ($/yr) | $413 | $567 | $631 |
| *Each new vessel* | *$7* | *$9* | *$61* |

## 0.0 VESSELS WITH GAS TURBINES AND DRY BILGE (DDG 51)

The only surface vessel class built with a dry bilge design is the Navy's latest class of guided missile destroyers, the USS ARLEIGH BURKE Class (DDG 51) which is the representative vessel class for the group. This vessel class has 33 active ships, and 18 ships in construction. The DDG 51 Class is powered by four GE LM 2500 gas turbines. In these vessels oily and non-oily machinery drain to segregated collection systems. Non-oily machinery drains are then pumped directly overboard and oily drains are pumped via the oily waste transfer system to the oily waste holding tank for processing by the oil/water separator.

### 0.0.0 DDG 51 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

During Phase II of UNDS, sampling was conducted on two vessels of the DDG 51 Class, USS CARNEY (DDG 64) and USS MAHAN (DDG 72), and serves as the primary source of chemical data for this vessel group. Sampling was conducted twice on DDG 64 because the first sampling collection process was determined to be flawed due to sample collection methods. Therefore, CARNEY was resampled and only the second set of data was used. DDG-72 was sampled 18 September 2000 through 23 October 2000; The DDG-64 was sampled 15-17 June 1999 and 29-30 June 1999. The samples were analyzed by Q Biochem (formally ETS Analytical Services), Pacific Analytical, Inc., and Columbia Analytical through Pacific Analytical, Inc. The results were reviewed by EPA and DoD to determine the quality of the analytical data; however some sample data were excluded in the final calculations, as documented in the *Draft Sampling Episode Report-USS CARNEY* (Navy, 2001a) and *Draft Sampling Episode Report- USS MAHAN* (Navy, 2000b), based upon Sample Control Center (SCC) review. As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

The characterization of the bilgewater discharge after secondary treatment by ultrafiltration could not be performed based on sample analysis because this operation is not in everyday practice aboard this vessel class. Discharge composition properties were estimated using Putnam and Singerman (2001) calculations as well as comparisons to the performance achieved by ultrafiltration on CVN 68 Class vessels. Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.5.2 DDG 51 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-14.

**Table 3-14. DDG 51 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD* (Gravity Coalescer) | 62.5 $ft^3$<br>1,250 lbs (dry)<br>2,710 lbs (flooded)<br>No impact | No impact | No impact | 18 hrs | 77 hrs | None | Electrical power—440 VAC, 60Hz<br>Potable water—potential primer<br>Sea water—primer<br>Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 134 $ft^3$<br>2,650 lbs (dry)<br>2,700 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 29 hrs | 45 hrs | Minimal consumables required; special tools required, but included in the initial purchase | Electrical power—440 VAC<br>Compressed Air – 0.0058-0.029 cfm at 50 psig<br>Potable water—20 gpd at 45 psi<br>Sea water—25 psi<br>Gravity drain | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 56 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after five days | Significant impact after five days | Significant impact after five days | Significant impact after five days | NA | None | None | None | None |
| Evaporation | **NF** – excessive power requirements | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Hydrocyclone | 17 $ft^3$<br>132 lbs (dry)<br>150 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 10.5 hrs | 51 hrs | Consumables and repair parts required (e.g., “O” rings, gaskets for cyclone, cyclone liners, and pump components) | Compressed Air – 18 scfm at 65 psi | Automated control panel; tank level switches; can be equipped with OCM | None |
| *In Situ* Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | 16.9 $ft^3$<br>730 lbs (dry)<br>1675 lbs (flooded)<br>Relocation of piping, furniture, and equipment would be required | No impact | No impact | 0.23 hrs | NA | Requires replacement of filter media canisters | None | Automatic operation in response to primary OWS | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |
| Membrane Filtration | 227.5 $ft^3$<br>2,700 lbs (dry)<br>3,000 lbs (flooded)<br>Some space and weight impacts | No impact | No impact | 9.85 hrs | NA | Requires replacement of membranes (performed shoreside)<br>No consumables or special tools required | Electrical power—440VAC, 60Hz<br>Compressed Air—80-100 psi, 5 scfm<br>Potable water—10 gpm at 30 psi<br>Gravity drain | Automatic operation in response to primary OWS | None |

**Table 3-15. DDG 51 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Initial Inside 12 nm/ Inside+Beyond 12 nm | 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Annualized Inside 12 nm/ Inside+Beyond 12 nm | Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 4.6/19 | .4/1.6 | 4.6/19 |
| Centrifuge | 210/210 | 6.9/11 | 18.4/18.8 | 217/221 |
| CHT (within current holding capacity) | 0/0 | 61/61 | 5.2/5.2 | 61/61 |
| Hydrocyclone | 62.6/62.6 | 2.8/13.4 | 5.6/6.5 | 65.4/76 |
| Filter Media | 84/84 | 18/18 | 8.8/8.8 | 104/104 |
| Membrane Filtration | 280/280 | 2.4/2.4 | 24/24 | 282/282 |

## 0.0.0 DDG 51 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-16 and Table 3-17.

**Table 3-16. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Vessels with Gas Turbines and Dry Bilge (DDG 51)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment plus Filter Media[1] | Primary Treatment plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Ammonia as Nitrogen | 2.3E+02 | 9.7E+03 | 9.7E+03 | 8.5E+03 | 4.8E+03 | 0 |
| Cadmium | 5.0E+00 | 4.3E+00[3] | 2.7E+00[3] | 1.3E+00[3] | ND | 0 |
| Copper | 2.4E+00 | 2.8E+01 | 2.2E+01 | 1.3E+01 | ND | 0 |
| Iron | 3.0E+02 | 2.0E+03 | 1.1E+03 | 1.6E+02[3] | 7.8E+01[3] | 0 |
| Lead | 5.6E+00 | 3.4E+01 | 1.7E+01 | 6.1E+00 | ND | 0 |
| Manganese | 1.0E+02 | 1.7E+02 | 1.7E+02 | 9.4E+01[3] | 2.8E+02 | 0 |
| Mercury | 2.5E-02 | 2.1E-01 | 2.0E-01 | 2.1E-01 | ND | 0 |
| Naphthalene | 1.4E+02 | 1.4E+02 | 7.2E+01[3] | 2.0E+01[3] | 4.4E+01[3] | 0 |
| Nickel | 8.3E+00 | 8.0E+02 | 4.7E+02 | 1.4E+02 | 1.2E+02 | 0 |
| Phenanthrene | 5.0E+00 | 4.6E+01 | 1.9E+01 | 1.2E+01 | ND | 0 |
| Selenium | 1.0E+01 | 4.4E+00[3] | 9.2E+00[3] | 1.4E+01 | 4.3E+00[3] | 0 |
| Silver | 1.0E-01 | 7.6E+00 | 6.2E+00 | ND | ND | 0 |
| Thallium | 6.3E+00 | 4.5E+00[3] | 5.7+00[3] | ND | 1.2E+01 | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 1.6E+02 | 1.1E+02 | 6.1E+01 | 3.0E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 2.4E+02 | 1.2E+02 | 4.2E+01 | 5.5E+01 | 0 |
| Tributyltin | 2.0E-03 | ND | 4.8E-02 | ND | 2.1E-02 | 0 |
| Zinc | 5.0E+01 | 2.0E+03 | 1.2E+03 | 4.7E+02 | 1.5E+01[3] | 0 |
| **Number of Constituents exceeding strictest WQC** | - | **13** | **13** | **10** | **7** | **0** |
| **Total Exceeded Numeric Criteria** | - | **84** | **93** | **56** | **28** | **0** |

*1 Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

*2 CHT does not release constituents to the receiving waters within 12 nm.*

*3 This concentration does not exceed water quality criteria.*

*ND = Not Detected*

**Table 3-17. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (DDG 051)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| 2-Methylnapthalene | 9.7E+00 | ND | ND | ND | 0 |
| *TPE:* | *1.6E+00* | | | | |
| 4-Chloro-3-Methylphenol | ND | ND | ND | 5.5E-01 | 0 |
| *TPE:* | | | | *2.4E-03* | |
| Acenaphthene | 1.1E+00 | 7.2E-01 | ND | ND | 0 |
| *TPE:* | *1.1E-02* | *7.2E-03* | | | |
| Ammonia as Nitrogen | 5.0E+02 | 5.0E+02 | 4.4E+02 | 2.5E+02 | 0 |
| *TPE:* | *4.1E+00* | *4.1E+00* | *3.6E+00* | *2.0E+00* | |
| Beryllium | 8.0E-02 | 6.7E-02 | ND | 8.1E-02 | 0 |
| *TPE:* | *8.5E-02* | *7.1E-02* | | *8.6E-02* | |
| Bis (2-Ethylhexyl) Phthalate | 1.2E+00 | 7.6E-01 | ND | ND | 0 |
| *TPE:* | [3] | [3] | | | |
| Cadmium | 2.2E-01 | 1.4E-01 | 6.6E-02 | ND | 0 |
| *TPE:* | *1.5E-01* | *9.4E-02* | *4.4E-02* | | |
| Chlorobenzene | 5.5E-01 | ND | ND | ND | 0 |
| *TPE:* | *3.1E-03* | | | | |
| Copper | 1.3E+02 | 6.6E+01 | 1.6E+01 | ND | 0 |
| *TPE:* | *2.4E+02* | *1.2E+02* | *2.8E+01* | | |
| Dibenzofuran | 1.2E+00 | 1.0E+00 | ND | ND | 0 |
| *TPE:* | *2.5E-01* | *2.2E-01* | | | |
| Fluorene | 1.8E+00 | 8.1E-01 | 5.5E-01 | 5.3E-01 | 0 |
| *TPE:* | *9.9E-02* | *4.5E-02* | *3.1E-02* | *3.0E-02* | |
| Iron | 1.0E+02 | 5.6E+01 | ND | ND | 0 |
| *TPE:* | *1.8E-01* | *9.5E-02* | | | |
| Lead | 1.7E+00 | 8.6E-01 | 3.2E-01 | ND | 0 |
| *TPE:* | *1.2E+00* | *6.1E-01* | *2.2E-01* | | |
| Manganese | 9.0E+00 | 8.8E+00 | ND | 1.4E+01 | 0 |
| *TPE:* | *5.6E+00* | *5.3E+00* | | *8.8E+00* | |
| Mercury | 1.1E-02 | 1.0E-02 | 1.1E-02 | ND | 0 |
| *TPE:* | *1.3E+00* | *1.2E+00* | *1.3E+00* | | |
| Naphthalene | 7.0E+00 | 3.7E+00 | 1.0E+00 | 2.3E+00 | 0 |
| *TPE:* | *3.3E-01* | *1.7E-01* | *4.8E-02* | *1.1E-01* | |
| Nickel | 4.1E+01 | 2.5E+01 | 7.5E+00 | 6.1E+00 | 0 |
| *TPE:* | *2.8E+01* | *1.7E+01* | *5.1E+00* | *4.2E+00* | |
| Nitrate/Nitrite | 1.0E+01 | 8.1E+00 | ND | ND | 0 |
| *TPE:* | *9.5E-01* | *7.5E-01* | | | |

| Discharge Constituent | | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Oil and Grease (HEM[4]) | | 8.8E+03 | 2.4E+03 | 7.2E+02 | 4.9E+02 | 0 |
| | *TPE:* | | | | | |
| Phenanthrene | | 2.4E+00 | 1.0E+00 | 6.2E-01 | ND | 0 |
| | *TPE:* | *1.2E+00* | *5.1E-01* | *3.1E-01* | | |
| Selenium | | 2.3E-01 | 4.8E-01 | 7.2E-01 | 2.2E-01 | 0 |
| | *TPE:* | *1.8E-02* | *3.8E-02* | *5.7E-02* | *1.8E-02* | |
| Silver | | 3.9E-01 | 3.2E-01 | ND | ND | 0 |
| | *TPE:* | *1.2E+01* | *9.5E+00* | | | |
| Sulfate | | 5.1E+03 | 5.2E+03 | 4.2E+03 | 7.9E+03 | 0 |
| | *TPE:* | *2.8E-02* | *2.9E-02* | *2.3E-02* | *4.4E-02* | |
| Thallium | | ND | ND | ND | 6.0E-01 | 0 |
| | *TPE:* | | | | *5.3E-01* | |
| Total Sulfide | | 1.8E+02 | 2.3E+02 | 1.8E+02 | 5.1E+02 | 0 |
| | *TPE:* | *5.0E+02* | *6.5E+02* | *4.9E+02* | *1.4E+03* | |
| Tributyltin | | ND | 2.5E-03 | ND | 1.1E-03 | 0 |
| | *TPE:* | | *1.4E+00* | | *6.2E-01* | |
| Zinc | | 1.0E+02 | 6.0E+01 | 2.4E+01 | 7.5E-01 | 0 |
| | *TPE:* | *7.1E+00* | *4.1E+00* | *1.7E+00* | *5.2E-02* | |
| **Total TPE Load** | | **8.3E+02** | **8.4E+02** | **5.5E+02** | **1.5E+03** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-18. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Vessels with Gas Turbines and Dry Bilge (DDG 51)**

| | Baseline Bilgewater | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 13 | 13 | 10 | 7 | 0 |
| Total Number of Exceeded Numeric WQC | 83 | 93 | 56 | 28 | 0 |
| Number of Exceeded Narrative Categories | 10 | 10 | 3 | 5 | 0 |
| Discharge HI at EOMZ | 1.6E+01 | 9.8E+00 | 4.4E+00 | 9.0E+00 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 13 | 12 | 9 | 4 | 0 |
| Discharge TPE | 8.3E+02 | 8.4E+02 | 5.5E+02 | 1.5E+03 | 0 |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is superior for most of the analysis methods (e.g., criteria exceedance and HI), to primary treatment alone with the exception of total discharge TPE.

Due to high measured values of sulfides in membrane filtration samples, the discharge TPE value for membrane filter analysis is unexpectedly higher than for primary treatment alone. This may be due to sulfate reduction by anaerobic bacteria (anaerobic conditions are known to occur in bilges and oily water holding tanks of vessels.) A determination of the cause of these high sulfide levels is beyond the scope of the UNDS sampling and analysis effort. Because the weighting of analysis methods would be subjective, and each of the three treatment options is better in some ways than others, the three options rank equally.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration, primary treatment plus filter media, primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 DDG 51 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-19. Values would not be applicable for membrane filtration analysis because, as discussed in the previous section (Section 3.5.3), the total discharge TPE value actually increased between primary and secondary treatment in this case.

**Table 3-19. TPEs Removed for each MCPD Option and Associated Costs (DDG 51)**

| | Filter Media | CHT |
|---|---|---|
| TPE removed from primary discharge by listed treatment | 2.00E+02 | 8.80E+02 |
| Cost per TPE removed over primary treatment ($/yr) | $2,156 | $290 |

## 0.0 VESSELS WITH GAS TURBINES AND WET BILGE (DD 963)

The Navy is the only branch of the Armed Forces that owns vessels powered exclusively by gas turbines. These vessels include guided missile cruisers, destroyers, frigates, and fast combat support ships. Amphibious landing craft air cushion (LCACs) are also powered by gas turbines. However, amphibious vehicles are not regulated by UNDS and are therefore not included in the vessel grouping (40 CFR 1700.1). Two Coast Guard vessel classes (WHEC 378 and WAGB 399) and one Navy research vessel class (UB 165) are powered by combined CI and gas turbine (CODOG) systems. These CODOG vessels rely on their CI engines for routine operations at cruise speed, and occasionally use gas turbine for high speeds for certain situations (e.g., rescues) (Volpe, 2000). Therefore, these vessels were grouped with other vessel groups rather than the gas turbine vessel group.[2] All of the vessels included in the group range from 445 ft to 950 ft in length and from 2769 tons to 2900 tons in displacement. Vessels in this group operate beyond 12 nm from shore except when transiting to and from port and training. These vessels use GE LM 2500 gas turbines for propulsion. Three vessel classes, DD 963, CG 47, and AOE 6, which collectively account for 56 % of the hulls in the group, use four gas turbines. The other vessel classes (i.e., the FFG 7 and T-AKR 310) use two gas turbines.

### 0.0.0 DD 963 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

During Phase II, sampling was conducted aboard one vessel of the DD 963 Class, the USS DAVID R. RAY (DD 971), on January 10-18 and February 7-11, 2000. These sampling episodes serve as the primary source of chemical data for this vessel group. Three bilgewater/ OWS discharge samples were collected during the first underway period and a fourth sample was collected during the second underway period. The samples were analyzed by Ecology and Environment, Inc., Pacific Analytical, Inc., and Q Biochem (formally ETS Analytical Services, Inc.). The results were reviewed by EPA and DoD to determine the quality of the analytical data; however some sample data were excluded in the final calculations, as documented in the *Draft Sampling Episode Report -USS DAVID R. RAY* (Navy, 2000c), based upon SCC review.

[2] *The Coast Guard WHEC 378 and WAGB 399 were grouped with vessels that process both bilgewater and dirty ballast water through their OWS. The Navy vessel class UB 165 (ex PG 84) was placed in the small CI ship vessel group.*

As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

The characterization of the bilgewater discharge after secondary treatment could not be performed based on sample analysis because this operation is not in everyday practice aboard this vessel class. Discharge composition properties were estimated using Putnam and Singerman (2001) calculations as well as comparisons to the performance achieved by secondary treatment technology on other vessels. Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.6.2 DD 963 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-20.

**Table 3-20. DD 963 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD * (Gravity Coalescer) | 63 $ft^3$<br>1,250 lbs (dry)<br>2,710 lbs (flooded)<br>No impact | No impact | No impact | 122 hrs | 456 hrs | None | Electrical power—440VAC, 60Hz<br>Potable water—potential primer<br>Sea water—primer<br>Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 136.5 $ft^3$<br>2,650 lbs (dry)<br>2,700 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 91 hrs | 260 hrs | Minimal consumables required. Special tools required, but included in the initial purchase. | Electrical power—440VAC, 60-100kW<br>Compressed Air--0.0058-0.029 scfm @ 50 psig<br>Potable water—20 gpd, 45 psi<br>Sea water—25 psi<br>Gravity drain | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 270 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after one day | Significant impact after one day | Significant impact after one day | Significant impact after one day | NA | None | None | None | None |
| Evaporation | **NF** – excessive power requirements | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Hydrocyclone | 17 $ft^3$<br>132 lbs (dry)<br>150 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 81.5 hrs | 300 hrs | Minimal consumables required. | Compressed Air: 18 scfm at 65 psi | Automated control panel; tank level switches; can be equipped with OCM | None |
| *In-Situ* Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | 16.9 $ft^3$<br>730 lbs (dry)<br>1675 lbs (flooded)<br>Relocation of existing furniture required | No impact | No impact | 2 hrs | NA | Requires replacement of filter media canisters | None | Automatic operation in response to primary OWS | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |
| Membrane Filtration | 227.5 $ft^3$<br>2,700 lbs (dry)<br>3,000 lbs (flooded)<br>No impact | No impact | No impact | 35 hrs | NA | Requires replacement of membranes (performed shoreside) | Electrical power—440VAC, 60Hz<br>CompressedAir—80-100 psi, 5 scfm<br>Potable water—10 gpm, 30 psi<br>Gravity drain | Automatic operation in response to primary OWS | None |

**Table 3-21. DD 963 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Initial Inside 12 nm/ Inside+Beyond 12 nm | 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Annualized Inside 12 nm/ Inside+Beyond 12 nm | Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 31/150 | 2.7/13 | 31/150 |
| Centrifuge | 247/247 | 23/90 | 22.9/28.6 | 270/337 |
| CHT (within current holding capacity) | 0/0 | 473/473 | 40.2/40.2 | 473/473 |
| Hydrocyclone | 102.5/102.5 | 21/97 | 11/17 | 123/200 |
| Filter Media | 85/85 | 160/160 | 21/21 | 250/250 |
| Membrane Filtration | 300/300 | 8.8/8.8 | 26/26 | 310/310 |

## 0.0.0 DD 963 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-22 and Table 3-23.

**Table 3-22. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Vessels with Gas Turbines and Wet Bilge (DD 963)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Ammonia as Nitrogen | 2.3E+02 | 4.1E+03 | 4.2E+03 | 4.2E+03 | 4.2E+03 | 0 |
| Copper | 2.4E+00 | 1.6E+01 | 1.3E+01 | 1.3E+01 | 1.3E+01 | 0 |
| Iron | 3.0E+02 | 3.5E+03 | 3.3E+02 | 1.3E+03 | 1.6E+03 | 0 |
| Manganese | 1.0E+02 | 2.1E+02 | 2.2E+02 | 2.2E+02 | 2.1E+02 | 0 |
| Naphthalene | 1.4E+02 | 2.5E+01[3] | 1.4E+01[3] | ND | ND | 0 |
| Nickel | 8.3E+00 | 2.5E+02 | 2.4E+02 | 1.8E+02 | 1.8E+02 | 0 |
| Phenanthrene | 5.0E+00 | 1.3E+01 | 1.0E+01 | ND | ND | 0 |
| Selenium | 1.0E+01 | 2.3E+01 | ND | ND | ND | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 1.1E+02 | 9.8E+01 | 9.8E+01 | 9.5E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 5.0E+01 | 2.4E+01 | ND | ND | 0 |
| Zinc | 5.0E+01 | 1.8E+03 | 1.8E+03 | 1.1E+03 | 4.1E+02 | 0 |
| **Number of Constituents Exceeding Strictest WQC** | - | **10** | **9** | **7** | **7** | **0** |
| **Total Exceeded Numeric Criteria** | - | **65** | **64** | **60** | **60** | **0** |

*[1] Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

*[2] CHT does not release constituents to the receiving waters within 12 nm.*

*[3] This concentration does not exceed water quality criteria.*

*ND = Not detected*

**Table 3-23. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (DD 963)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Ammonia as Nitrogen | 1.8E+03 | 1.8E+03 | 1.8E+03 | 1.8E+03 | 0 |
| *TPE:* | *1.4E+01* | *1.5E+01* | *1.5E+01* | *1.5E+01* | |
| Bis (2-Ethylhexyl) Phthalate | ND | 4.8E+00 | ND | ND | 0 |
| *TPE:* | | [3] | | | |

| Discharge Constituent | | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Cadmium | | 6.9E-01 | 6.5E-01 | 6.5E-01 | ND | 0 |
| | *TPE:* | *4.6E-01* | *4.3E-01* | *4.3E-01* | | |
| Copper | | 2.4E+02 | 2.3E+02 | 1.1E+02 | 5.0E+01 | 0 |
| | *TPE:* | *4.3E+02* | *4.1E+02* | *2.1E+02* | *9.1E+01* | |
| Fluorene | | 5.2E+00 | ND | ND | ND | 0 |
| | *TPE:* | *2.9E-01* | | | | |
| Iron | | 1.5E+03 | 1.5E+03 | 5.8E+02 | 7.2E+02 | 0 |
| | *TPE:* | *2.6E+00* | *2.5E+00* | *9.9E-01* | *1.2E+00* | |
| Lead | | 8.7E-01 | 8.3E-01 | 8.3E-01 | 6.2E-01 | 0 |
| | *TPE:* | *6.0E-01* | *5.8E-01* | *5.8E-01* | *4.3E-01* | |
| Manganese | | 9.3E+01 | 9.5E+01 | 9.5E+01 | 9.3E+01 | 0 |
| | *TPE:* | *5.7E+01* | *5.8E+01* | *5.8E+01* | *5.7E+01* | |
| Naphthalene | | 1.1E+01 | 6.2E+00 | ND | ND | 0 |
| | *TPE:* | *5.1E-01* | *2.9E-01* | | | |
| Nickel | | 1.1E+02 | 1.1E+02 | 7.9E+01 | 8.0E+01 | 0 |
| | *TPE:* | *7.5E+01* | *7.2E+01* | *5.4E+01* | *5.4E+01* | |
| Oil and Grease (HEM[4]) | | 1.4E+04 | 6.1E+03 | ND | ND | 0 |
| | *TPE:* | | | | | |
| Phenanthrene | | 5.8E+00 | 4.4E+00 | ND | ND | 0 |
| | *TPE:* | *3.0E+00* | *2.2E+00* | | | |
| Selenium | | 9.9E+00 | ND | ND | ND | 0 |
| | *TPE:* | *7.9E-01* | | | | |
| Sulfate | | 5.0E+05 | 4.7E+05 | 4.7E+05 | 4.7E+05 | 0 |
| | *TPE:* | *2.8E+00* | *2.7E+00* | *2.7E+00* | *2.7E+00* | |
| Total Sulfide | | 1.2E+03 | 8.2E+02 | ND | ND | 0 |
| | *TPE:* | *3.5E+03* | *2.3E+03* | | | |
| Zinc | | 7.7E+02 | 7.9E+02 | 4.7E+02 | 1.8E+02 | 0 |
| | *TPE:* | *5.3E+01* | *5.5E+01* | *3.3E+01* | *1.2E+01* | |
| **Total TPE Load** | | **4.3E+03** | **3.1E+03** | **5.5E+02** | **4.1E+02** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-24. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Vessels with Gas Turbines and Wet Bilge (DD 963)**

| | Baseline Bilgewater | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 10 | 9 | 7 | 7 | 0 |
| Total Number of Exceeded Numeric WQC | 65 | 64 | 60 | 60 | 0 |
| Number of Exceeded Narrative Categories | 7 | 7 | 2 | 3 | 0 |
| Discharge HI at EOMZ | 7.6E+00 | 6.0E+00 | 2.3E+00 | 1.5E+00 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 8 | 7 | 4 | 3 | 0 |
| Discharge TPE | 4.3E+03 | 3.1E+03 | 5.5E+02 | 4.1E+02 | 0 |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is superior for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. For most analysis methods, membrane filtration technology provided superior performance in terms of the environmental effects analysis methods used in this report. However, uncertainty due to potential inaccuracies of filter media performance because of channeling suggests that the filter media may not provide the environmental performance evidenced by these results. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
3. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 DD 963 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-25.

**Table 3-25. TPEs Removed for each MCPD Option and Associated Costs (DD 963)**

| | Filter Media | Membrane Filtration | CHT |
|---|---|---|---|
| TPE removed from primary discharge by listed treatment | 2.50E+03 | 2.63E+03 | 3.30E+03 |
| Cost per TPE removed over primary treatment ($/yr) | $731 | $860 | $1,060 |

## 3.7 DIESEL SHIPS OWS PROCESS BILGEWATER AND DIRTY BALLAST (WHEC 378)

This group consists of 28 Coast Guard cutters distributed among three vessel classes: medium endurance cutters WMEC 210 (14 hulls), high endurance cutters WHEC 378 (12 hulls), and ice breakers WAGB 399 (2 hulls). The first class has CI propulsion while the latter two classes have both CI and gas turbine (CODOG) propulsion. However, CODOG vessels use their CI engines for routine operations at cruise speed, and occasionally use gas turbine for high-speed situations (e.g., rescues). Vessels in this group process their dirty ballast water through the same OWS used to process bilgewater. Therefore, they are equipped with an OWS four to ten times larger than comparably sized vessels that only process bilgewater. These vessels operate both inside and outside 12 nm from shore.

### 3.7.1 WHEC 378 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

During UNDS Phase II, sampling was conducted aboard one vessel of the WHEC 378 Class, USCGC MORGENTHAU (WHEC 722) from 30 August 1999 to 7 September 1999 and 13-19 November 1999. These sampling episodes serve as the primary source of chemical data for this vessel group. Two bilgewater/ OWS discharge samples were collected during each of the underway periods. The samples were analyzed by Ecology and Environment, Inc., Pacific Analytical, Inc., and Q Biochem (formally ETS Analytical Services, Inc.). The results were reviewed by EPA and DoD to determine the quality of the analytical data. However, some sample data were excluded in the final calculations as documented in the *Draft Sampling Episode Report–USCGC MORGENTHAU* (Navy, 2000d), based on Sample Control Center (SCC) review. As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.7.2 WHEC 378 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-26.

**Table 3-26. WHEC 378 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) Within 12 nm (inc. maintenance) | Personnel Impact (operator labor hrs/year) Beyond 12 nm | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| Current MPCD* (Gravity Coalescer) | 130 $ft^3$<br>1,400 lbs (dry)<br>4,300 (flooded)<br>No impact | No impact | No impact | 19.3 hrs | 1.8 hrs | None | Electrical power—440VAC, 60Hz, motor – 1.5 HP<br>Sea water—primer<br>Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 393 $ft^3$<br>6,610 lbs (dry)<br>7,385 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 21.1 hrs | 1.6 hrs | Minimal consumables required. Special tools required, but included in the initial purchase. | Electrical power.—440VAC, 80-130kW<br>Compressed Air--.0058-.029 scfm @ 50 psig<br>Potable water—50 gpd, 45 psi<br>Gravity drain | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 2.9 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after five days | Significant impact after five days | Significant impact after five days | Significant impact after five days | NA | None | None | None | None |
| Evaporation | **NF** – excessive power requirements | | | | | | | | |
| Hydrocyclone | 168 $ft^3$<br>900 lbs (dry)<br>1,000 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 6.3 hrs | 1.6 hrs | Minimal consumables and repair parts required | Electrical power—440VAC, 60Hz | Automated control panel | None |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| In-Situ Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | **NF –** potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | **NF** – adequate space is not available | | | | | | | | |
| Membrane Filtration | **NF** – adequate space is not available | | | | | | | | |

**Table 3-27. WHEC 378 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Initial Inside 12 nm/ Inside+Beyond 12 nm | 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Annualized Inside 12 nm/ Inside+Beyond 12 nm | Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 5.46/3.25 | 0.464/0.277 | 5.46/3.25 |
| Centrifuge | 632/632 | 5.65/3.02 | 54/53.9 | 637/635 |
| CHT (within current holding capacity) | 0/0 | 59.89/59.89 | 5.09/5.09 | 59.89/59.89 |
| Hydrocyclone | 220/220 | 2.18/3.20 | 18.9/19.0 | 222/223 |

## 0.0.0 WHEC 378 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-28.

**Table 3-28. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline and MPCD Discharges from Compression Ignition Ships that OWS Process Bilgewater and Dirty Ballast (WHEC 378)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | CHT[1] |
|---|---|---|---|---|
| Ammonia as Nitrogen | 2.3E+02 | 5.8E+02 | 5.4E+02 | 0 |
| Boron | 8.1E+03 | 5.6E+03[2] | 5.4E+03[2] | 0 |
| Cadmium | 5.0E+00 | 6.3E+00 | 6.7E+00 | 0 |
| Chlorinated Naphthalenes | 7.5E+00 | 2.8E+01 | ND | 0 |
| Copper | 2.4E+00 | 1.4E+01 | 1.7E+01 | 0 |
| Iron | 3.0E+02 | 3.5E+03 | 4.0E+03 | 0 |
| Lead | 5.6E+00 | 2.7E+01 | 3.0E+01 | 0 |
| Manganese | 1.0E+02 | 3.6E+02 | 3.6E+02 | 0 |
| Naphthalene | 1.4E+02 | 3.3E+01[2] | 1.4E+02 | 0 |
| Nickel | 8.3E+00 | 2.2E+02 | 2.3E+02 | 0 |
| Phenanthrene | 5.0E+00 | 3.0E+01 | 2.8E+01 | 0 |
| Thallium | 6.3E+00 | 9.9E+00 | 8.2E+00 | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 2.3E+02 | 2.7E+02 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 9.5E+01 | 2.0E+02 | 0 |
| Zinc | 5.0E+01 | 2.5E+03 | 2.9E+03 | 0 |
| **Number Of Constituents Exceeding Strictest WQC** | - | **13** | **13** | **0** |
| **Total Exceeded Numeric Criteria** | - | **85** | **86** | **0** |

[1] *CHT does not release constituents to the receiving waters.*

[2] *Does not exceed criteria*

*ND = Not detected*

**Table 3-29. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (WHEC 378)**

| Discharge Constituent | Baseline | Primary Treatment | CHT[1] |
|---|---|---|---|
| 2-Chloronaphthalene | 1.1E-01 | ND | 0 |
| *TPE:* | *1.7E-02* | | |
| 2-Methylnaphthalene | ND | 1.0E+00 | 0 |
| *TPE:* | | *1.6E-01* | |
| Ammonia as Nitrogen | 2.3E+00 | 2.1E+00 | 0 |
| *TPE:* | *1.8E-02* | *1.7E-02* | |
| Boron | 2.2E+01 | 2.1E+01 | 0 |
| *TPE:* | *3.9E+00* | *3.8E+00* | |

| Discharge Constituent | Baseline | Primary Treatment | CHT[1] |
|---|---|---|---|
| Cadmium | 2.5E-02 | 2.6E-02 | 0 |
| *TPE:* | *1.7E-02* | *1.8E-02* | |
| Chlorobenzene | 4.8E-02 | 5.1E-02 | 0 |
| *TPE:* | *2.7E-04* | *2.9E-04* | |
| Copper | 1.8E+00 | 2.2E+00 | 0 |
| *TPE:* | *3.2E+00* | *4.0E+00* | |
| Fluorene | 1.2E-01 | 1.1E-01 | 0 |
| *TPE:* | *7.0E-03* | *6.0E-03* | |
| Iron | 1.4E+01 | 1.6E+01 | 0 |
| *TPE:* | *2.3E-02* | *2.7E-02* | |
| Lead | 1.1E-01 | 1.2E-01 | 0 |
| *TPE:* | *7.3E-02* | *8.1E-02* | |
| Manganese | 1.4E+00 | 1.4E+00 | 0 |
| *TPE:* | *8.6E-01* | *8.6E-01* | |
| Naphthalene | 1.3E-01 | 5.6E-01 | 0 |
| *TPE:* | *6.0E-03* | *2.6E-02* | |
| Nickel | 8.5E-01 | 9.1E-01 | 0 |
| *TPE:* | *5.8E-01* | *6.2E-01* | |
| Oil and Grease (HEM[3]) | 6.3E+02 | 5.1E+02 | 0 |
| *TPE:* | | | |
| Phenanthrene | 1.2E-01 | 1.1E-01 | 0 |
| *TPE:* | *6.0E-02* | *5.6E-02* | |
| Sulfate | 8.9E+02 | 8.6E+02 | 0 |
| *TPE:* | *5.0E-03* | *4.8E-03* | |
| Thallium | 3.9E-02 | 3.2E-02 | 0 |
| *TPE:* | *3.4E-02* | *2.9E-02* | |
| Total Sulfide | 1.5E+01 | 7.5E+00 | 0 |
| *TPE:* | *4.3E+01* | *2.1E+01* | |
| Zinc | 9.8E+00 | 1.1E+01 | 0 |
| *TPE:* | *6.8E-01* | *7.8E-01* | |
| **Total TPE Load** | **5.3E+01** | **3.2E+01** | **0** |

[1] *CHT does not release constituents to the receiving waters.*

[2] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[3] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-30. Summary of EEA for Baseline and MPCD Discharges from Compression Ignition Ships that OWS Process Bilgewater and Dirty Ballast (WHEC 378)**

| | Baseline Bilgewater | Primary Treatment | CHT |
|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 13 | 13 | 0 |
| Total Number of Exceeded Numeric WQC | 85 | 86 | 0 |
| Number of Exceeded Narrative Categories | 7 | 7 | 0 |
| Discharge HI at EOMZ | 1.6E+00 | 1.1E+00 | 0 |
| Potential for NIS Release | Low | Low | None |
| Number of BCCs Identified | 9 | 8 | 0 |
| Discharge TPE | 5.3E+01 | 3.2E+01 | 0 |

In summary, the application of CHT to bilgewater has the least environmental impact because there is no discharge to the receiving water. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 WHEC 378 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-31.

**Table 3-31. TPEs Removed for each MCPD Option and Associated Costs (WHEC 378)**

| | CHT |
|---|---|
| TPE removed from primary discharge by listed treatment | 3.90E+03 |
| Cost per TPE removed over primary treatment ($/yr) | $39 |

## 0.0 LARGE COMPRESSION IGNITION VESSELS (LSD 41)

This group consists of large CI ships of the Navy, MSC, and Coast Guard with displacements at or above 6000 tons. Vessels in this group include amphibious transport dock ships, combat stores ships, oilers, cable repairing ships, research and surveillance ships, surveying ships, ocean tugs, and logistic support ships. These large size vessels range from 420 ft to 950 ft in length and from 8,300 to 36,000 tons of displacement. Because of the large size of these ships, they primarily operate in ocean waters outside 12 nm from shore, except when on training exercises or transiting to and from port. Ships in this vessel group have between 1 to 5 propulsion engines, with approximately 50 % using four engines. All vessels in the group have substantial auxiliary machinery and equipment, and the vast majority have multiple propeller shafts.

### 3.8.1 LSD 41 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

During UNDS Phase II, sampling was conducted aboard two vessels of the LSD 41 Class, USS OAK HILL (16-17 November), and USS RUSHMORE (26 September 2000, 17 October 2000, 17 November 2000, and 13 December 2000). These two sampling episodes serve as the primary sources of chemical data for this vessel group. The samples were analyzed by Ecology and Environment, Inc., Pacific Analytical, Inc., Columbia Analytical Services (through Pacific Analytical, Inc.) and Q Biochem laboratories (formally ETS Analytical Services, Inc.). The results were reviewed by EPA and DoD to determine the quality of the analytical data; however some sample data were excluded from the final calculations, as documented in the *Draft Sampling Episode Report – USS RUSHMORE* (Navy, 2001b) and *Draft Sampling Episode Report – USS OAK HILL* (Navy, 2000e), based upon Sample Control Center (SCC) review. As discussed in Section 3.1.3, pesticide results were not included in bilgewater discharge profiles (Navy and EPA, 2003d).

The characterization of the bilgewater discharge after secondary treatment by filter media could not be performed based on sample analysis because this operation is not in everyday practice aboard this vessel class. Discharge composition properties were estimated using Putnam and Singerman (2001) calculations as well as comparisons to the performance achieved by filter media on DDG 51 Class vessels. Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.8.2 LSD 41 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-32.

**Table 3-32. LSD 41 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD* (Gravity Coalescer) | 126 $ft^3$<br>2,500 lbs (dry)<br>5,420 lbs (flooded)<br>No impact | No impact | No impact | 79 hrs | 286 hrs | None | Electrical power – 440 VAC, 60 Hz<br>Potable water – potential primer<br>Sea water – primer<br>Gravity drain | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 137 $ft^3$<br>2,650 lbs (flooded)<br>2,700 lbs (flooded)<br>Existing OWS would be removed and replaced with unit | No impact | No impact | 91.75 hrs | 280 hrs | Minimal consumables required. Special tools required, but included in the initial purchase. | Electrical power—440VAC, 60-100kW<br>Compressed Air--0.0058-0.029 cfm @ 50 psig<br>Potable water—20 gpd, 45 psi<br>Sea water – 25 psi<br>Gravity drain | Automated control panel (vendor recommends operator oversight during startup), integrated thermostat to control heater, can be equipped with OCM | None |
| CHT—operating from port with shoreside facilities | No impact – within current holding capacity | No impact | No impact | 480 hrs | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after two days. | Significant impact after two days. | Significant impact after two days. | Significant impact after two days. | NA | None | None | None | None |
| Evaporation | **NF** – excessive power requirements | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Hydrocyclone | 17 $ft^3$ 132 lbs (dry) 150 lbs (flooded) OWS would be removed and replaced with unit | No impact | No impact | 55.5 hrs | 217 hrs | Minimal consumables and repair parts required | Compressed Air 27scfm @ 65 psi | Automated control panel; tank level switches; can be equipped with OCM | None |
| *In -Situ* Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | 16.9 $ft^3$ 730 lbs (dry) 1,675 lbs (flooded) Relocation of workbench and phone required | No impact | No impact | 2.0 hrs | NA | Requires replacement of filter media canisters | None | Automatic operations in response to primary OWS | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |
| Membrane Filtration | 227.5 $ft^3$ 2,700 lbs (dry) 3,000 lbs (flooded) Some space and weight impacts | No impact | No impact | 18.4 hrs | NA | Requires replacement of membranes (performed shoreside) | Electrical power—440VAC, 60Hz Compressed Air - 80-100 psi, 5 scfm Potable water—10 gpm, 30 psi Gravity drain | Automatic operation in response to primary OWS | None |

**Table 3-33. LSD 41 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Total Initial Inside 12 nm/ Inside+Beyond 12 nm | USCG Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | USCG Annualized Inside 12 nm/ Inside+Beyond 12 nm | USCG Total Ownership Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Annualized Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 68/333 | 5.8/28.3 | 68/333 | 20/92 | 1.7/7.8 | 20/92 |
| Centrifuge | 301/301 | 71.3/335 | 31.6/54.0 | 372/636 | 23.4/94.7 | 27.5/33.6 | 324/396 |
| CHT (within current holding capacity) | 0/0 | 4940/4940 | 420/420 | 4940/4940 | 520/520 | 44/44 | 520/520 |
| Hydrocyclone | 123/123 | 62.4/310 | 15.8/36.8 | 185/433 | 14.5/69 | 11.7/16.3 | 138/192 |
| Filter Media | 145/145 | 160/160 | 25.6/25.6 | 301/301 | 160/160 | 25.6/25.6 | 301/301 |
| Membrane Filtration | 330/330 | 52.34/52.34 | 32.2/32.2 | 380/380 | 4.65/4.65 | 28.1/28.1 | 331/331 |

## 0.0.0 LSD 41 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-34 and Table 3-35.

**Table 3-34. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| Ammonia as Nitrogen | 2.3E+02 | 1.2E+03 | 1.3E+00 | 1.3E+03 | 5.4E+02 | 0 |
| Copper | 2.4E+00 | 1.3E+01 | 1.5E+01 | 1.5E+01 | 8.1E+00 | 0 |
| Iron | 3.0E+02 | 3.4E+02 | 3.3E+02 | 1.3E+02[3] | 5.8E+01[3] | 0 |
| Lead | 5.6E+00 | 8.9E+00 | 9.8E+00 | 9.8E+00 | ND | 0 |
| Manganese | 1.0E+02 | 1.1E+02 | 1.1E+02 | 1.1E+02 | 1.2E+02 | 0 |
| Mercury | 2.5E-02 | ND | ND | ND | 2.0E-01 | 0 |
| Nickel | 8.3E+00 | 1.1E+02 | 1.1E+02 | 8.4E+01 | 3.4E+01 | 0 |
| Zinc | 5.0E+01 | 4.1E+02 | 4.5E+02 | 2.7E+02 | 1.9E+01[3] | 0 |
| Phenanthrene | 5.0E+00 | 1.1E+01 | 1.1E+01 | ND | ND | 0 |
| Thallium | 6.3E+00 | 1.5E+01 | 1.2E+01 | 1.2E+01 | 1.2E+01 | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 7.4E+01 | 7.7E+01 | 7.7E+01 | 6.9E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 2.4E+01 | 2.5E+01 | ND | 2.0E+01 | 0 |
| **Number Of Constituents Exceeding Strictest WQC** | - | **11** | **11** | **8** | **8** | **0** |
| **Total Exceeded Numeric Criteria** | - | **76** | **73** | **68** | **32** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *Does not exceed criteria.*

*ND = Not detected*

**Table 3-35. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (LSD 41)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Ammonia as Nitrogen | 4.8E+02 | 5.0E+02 | 5.0E+02 | 2.1E+02 | 0 |
| *TPE:* | *3.9E+00* | *4.0E+00* | *4.0E+00* | *1.7E+00* | |

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Cadmium | 9.0E-01 | 9.2E-01 | 9.2E-01 | ND | 0 |
| *TPE:* | *6.0E-01* | *6.1E-01* | *6.1E-01* | | |
| Copper | 7.7E+01 | 7.1E+01 | 3.6E+01 | 3.6E+00 | 0 |
| *TPE:* | *1.4E+02* | *1.3E+02* | *6.5E+01* | *6.6E+00* | |
| Iron | 1.3E+02 | 1.3E+02 | ND | ND | 0 |
| *TPE:* | *2.2E-01* | *2.2E-01* | | | |
| Lead | 3.4E+00 | 3.8E+00 | 3.8E+00 | ND | 0 |
| *TPE:* | *2.4E+00* | *2.6E+00* | *2.6E+00* | | |
| Manganese | 4.1E+01 | 4.2E+01 | 4.2E+01 | 4.6E+01 | 0 |
| *TPE:* | *2.5E+01* | *2.6E+01* | *2.6E+01* | *2.8E+01* | |
| Mercury | ND | ND | ND | 7.9E-02 | 0 |
| *TPE:* | | | | *9.2E+00* | |
| Naphthalene | 5.1E+00 | 5.6E+00 | ND | 7.7E+00 | 0 |
| *TPE:* | *2.4E-01* | *2.6E-01* | | *3.6E-01* | |
| Nickel | 4.3E+01 | 4.3E+01 | 3.3E+01 | 1.3E+01 | 0 |
| *TPE:* | *3.0E+01* | *3.0E+01* | *2.2E+01* | *9.0E+00* | |
| Nitrate/Nitrite | 1.1E+03 | 1.3E+03 | 7.8E+02 | ND | 0 |
| *TPE:* | *1.1E+02* | *1.2E+02* | *7.3E+01* | | |
| Oil and Grease (HEM[4]) | 1.1E+04 | 8.6E+03 | 2.5E+03 | 5.1E+03 | 0 |
| *TPE:* | | | | | |
| Phenanthrene | 4.4E+00 | 4.2E+00 | ND | ND | 0 |
| *TPE:* | *2.2E+00* | *2.1E+00* | | | |
| Selenium | 2.8E+00 | 2.7E+00 | 2.7E+00 | 1.4E+00 | 0 |
| *TPE:* | *2.2E-01* | *2.2E-01* | *2.2E-01* | *1.1E-01* | |
| Sulfate | 1.9E+05 | 1.9E+05 | 1.9E+05 | 1.7E+05 | 0 |
| *TPE:* | *1.1E+00* | *1.1E+00* | *1.1E+00* | *9.6E-01* | |
| Thallium | 6.0E+00 | 4.6E+00 | 4.6E+00 | 4.6E+00 | 0 |
| *TPE:* | *5.3E+00* | *4.1E+00* | *4.1E+00* | *4.1E+00* | |
| Total Sulfide | 1.2E+03 | 1.0E+03 | ND | 8.4E+02 | 0 |
| *TPE:* | *3.3E+03* | *2.9E+03* | | *2.3E+03* | |
| Zinc | 1.6E+02 | 1.7E+02 | 1.0E+02 | 7.2E+00 | 0 |
| *TPE:* | *1.1E+01* | *1.2E+01* | *7.2E+00* | *5.0E-01* | |
| **Total TPE Load** | **3.7E+03** | **3.3E+03** | **3.4E+02** | **2.5E+03** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

*3 No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND=Not Detected*

**Table 3-36. Summary of EEA for Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)**

| | Baseline Bilgewater | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 11 | 11 | 8 | 8 | 0 |
| Total Number of Exceeded Numeric WQC | 76 | 73 | 68 | 32 | 0 |
| Number of Exceeded Narrative Categories | 6 | 6 | 3 | 5 | 0 |
| Discharge HI at EOMZ | 1.6E+01 | 1.5E+01 | 4.2E+00 | 8.0E+00 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 7 | 7 | 5 | 5 | 0 |
| Discharge TPE | 3.7E+03 | 3.3E+03 | 3.4E+02 | 2.5E+03 | 0 |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is superior for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Primary treatment plus membrane filtration ranked ahead of filter media in regard to criteria exceedances, but resulted in higher HI and TPE values. However, uncertainty due to potential inaccuracies of filter media performance because of channeling suggests that the filter media may not provide the environmental performance evidenced by these results. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration, primary treatment plus filter media
3. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 LSD 41 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-37.

**Table 3-37. TPEs Removed for each MCPD Option and Associated Costs (LSD 41)**

| | Filter Media | Membrane Filtration | CHT |
|---|---|---|---|
| TPE removed from primary discharge by listed treatment | 3.32E+03 | 1.60E+03 | 4.30E+03 |
| Cost for non-USCG vessels per TPE removed over primary treatment ($/yr) | $393 | $896 | $522 |
| *Each new vessel* | *$7* | *$16* | *$25* |
| Cost for USCG vessels per TPE removed over primary treatment ($/yr) | $8 | $20 | $98 |
| *Each new vessel* | *$7* | *$18* | *$112* |

## 3.9 MEDIUM COMPRESSION IGNITION VESSELS (MCM 1)

Medium ships are defined as vessels with displacements at or above 400 tons but below 6000 tons. This group consists of medium sized CI ships of the Navy, MSC, Coast Guard, and Army, including tank landing ships, salvage ships, mine countermeasures, buoy tenders, research and surveillance ships, surveying ships, ocean tugs, and logistic support ships. Vessels in this group range from 128 ft to 522 ft in length, and from 534 tons to 4975 tons of displacement. Vessels in this group operate in both coastal and ocean waters outside 12 nm from shore. They have multiple propulsion engines and shafts, and substantial auxiliary machinery and equipment. The exception to this group was the inclusion of Navy floating dry docks (i.e., AFDL 1, AFDM 3, ARDM 1, ARDM 4, and IX 525 classes) and two USCG 120 ft barges (Barge 120), which do not have self propulsion, but that are equipped with multiple CI engines used for operation of pumps and as generators for auxiliary power. It is expected that these non-self propel vessels will generate bilgewater at rates and with oily constituents more similar to a medium diesel ship than to a barge that lacks engines or has minimal auxiliary machinery. An important consideration for the creation of this vessel group is that the smaller size of these vessels when compared with larger vessels (above 6000 tons) could place space limitations on the MPCDs considered.

### 3.9.1 MCM 1 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

Due to similarities in machinery, propulsion systems, and ancillary equipment, the LSD 41 vessel group discharge information is used to represent the MCM 1 vessel group.

Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.9.2 MCM 1 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-38.

## Table 3-38. MCM 1 Summary of Practicability and Operational Impact Analysis

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD* (Gravity Coalescer) | 15 $ft^3$<br>300 lbs (dry)<br>455 lbs (flooded)<br>No impact | No impact | No impact | 40.5 hrs | 36 hrs | None | Electrical power.—115/230VAC 60Hz Fresh, salt, or brackish water – pressure regulated to 15 psi | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 6.9 $ft^3$<br>132 lbs (dry)<br>OWS would be removed and replaced with unit | No impact | No impact | 35.75 hrs | 53 hrs | Minimal consumables and repair parts required | 440 VAC<br>Potable water- 1 gpd | Manual startup, OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 75.6 hr | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | Significant impact after 3 days | Significant impact after 3 days | Significant impact after 3 days | Significant impact after 3 days | NA | None | None | None | None |
| Evaporation | **NF** – adequate space not available; excessive power requirements | | | | | | | | |
| Hydrocyclone | 8 $ft^3$<br>88 lbs (dry)<br>100 lbs (flooded)<br>OWS would be removed and replaced with unit | No impact | No impact | 16.5 hrs | 27 hrs | Minimal consumables and repair parts required | Compressed Air – 65 psi, 12 scfm | Automated control panel, tank level switches | None |
| In-Situ Biological Treatment | **NF** – excessive bilgewater volume | | | | | | | | |
| Oil-Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Filter Media | 36 $ft^3$<br>1320 lbs (dry)<br>1900 lbs (flooded)[1]<br>Relocation of piping, furniture and equipment required | No impact | No impact | 0.11 hrs | 0 hrs | Requires filter media canisters, which need to be replaced every 400 hours of operation | None | None | Systems were removed from DDG because they failed to consistently produce effluent less than 15 ppm. |
| Membrane Filtration | 227.5 $ft^3$<br>2500 lbs (dry)[1] | No impact | No impact | 10.56 hrs | .51 hrs | Minimal consumables and repair parts required | 440 VAC, 60 hz<br>Compressed Air – 80-100 psi, 5 scfm<br>Potable Water – 10 gpm at 30 psi | None | None |

**Table 3-39. MCM 1 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Total Initial Inside 12 nm/ Inside+Beyond 12 nm | USCG Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | USCG Annualized Inside 12 nm/ Inside+Beyond 12 nm | USCG Total Ownership Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Annualized Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 12.9/26.8 | 1.10/2.279 | 12.9/26.8 | 10.1/19 | .861/1.62 | 10.1/19 |
| Centrifuge | 96/96 | 11.5/29.4 | 9.12/10.7 | 107/125 | 8.78/22.1 | 8.88/10 | 104/118 |
| CHT (within current holding capacity) | 0/0 | 294.9/294.9 | 25/06/25.06 | 294.9/294.9 | 41.8/41.8 | 3.55/3.55 | 41.8/41.8 |
| Hydrocyclone | 93/93 | 6.9/18.7 | 8.49/9.49 | 99.9/112 | 4.15/11 | 8.3/8.83 | 97/104 |
| Filter Media | 94/94 | 9.25/9.25 | 8.77/8.77 | 103/103 | 9.25/9.25 | 8.77/8.77 | 103/103 |
| Membrane Filtration | 410/410 | 2.65/2.65 | 35.1/35.1 | 413/413 | 2.65/2.65 | 35.1/35.1 | 413/413 |

## 0.0.0 MCM 1 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-40 and Table 3-41.

**Table 3-40. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Medium CI Ships (at or above 400 tons and under 6000 tons) (MCM 1 Based on LSD 41 Surrogate Data)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|---|
| **Saltwater:** | | | | | | |
| Ammonia as Nitrogen | 2.3E+02 | 1.2E+03 | 1.3E+03 | 1.3E+03 | 5.4E+02 | 0 |
| Cadmium | 5.0E+00 | 2.3E+00[3] | 2.4E+00[3] | 2.4E+00[3] | ND | 0 |
| Copper | 2.4E+00 | 1.3E+01 | 1.5E+01 | 1.5E+01 | 8.1E+00 | 0 |
| Iron | 3.0E+02 | 3.4E+02 | 3.3E+02 | 1.3E+02[3] | 5.8E+01[3] | 0 |
| Lead | 5.6E+00 | 8.9E+00 | 9.8E+00 | 9.8E+00 | ND | 0 |
| Manganese | 1.0E+02 | 1.1E+02 | 1.1E+02 | 1.1E+02 | 1.2E+02 | 0 |
| Mercury | 2.5E-02 | ND | ND | ND | 2.0E-01 | 0 |
| Nickel | 8.3E+00 | 1.1E+02 | 1.1E+02 | 8.4E+01 | 3.4E+01 | 0 |
| Phenanthrene | 5.0E+00 | 1.1E+01 | 1.1E+01 | ND | ND | 0 |
| Thallium | 6.3E+00 | 1.5E+01 | 1.2E+01 | 1.2E+01 | 1.2E+01 | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 7.4E+01 | 7.7E+01 | 7.7E+01 | 6.9E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 2.4E+01 | 2.5E+01 | ND | 2.0E+01 | 0 |
| Zinc | 5.0E+01 | 4.1E+02 | 4.5E+02 | 2.7E+02 | 1.9E+01[3] | 0 |
| **Freshwater:** | | | | | | |
| Cadmium | 1.1E+00 | 2.3E+00 | 2.4E+00 | 2.4E+00 | ND | 0 |
| Copper | 8.8E+00 | 1.3E+01 | 1.5E+01 | 1.5E+01 | 9.4E+00[3] | 0 |
| Zinc | 6.4E+01 | 9.8E+01 | 9.1E+01 | 9.1E+01 | 1.9E+01[3] | 0 |
| **Number Of Constituents Exceeding Strictest WQC** | **-** | **14** | **14** | **11** | **8** | **0** |
| **Total Exceeded Numeric Criteria** | **-** | **96** | **93** | **88** | **32** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *Value does not exceed criteria.*

*ND = Not detected*

**Table 3-41. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (MCM 1)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Saltwater: | | | | | |
| Ammonia as Nitrogen | 5.9E+01 | 6.1E+01 | 6.1E+01 | 2.5E+01 | 0 |
| *TPE:* | *4.8E-01* | *5.0E-01* | *5.0E-01* | *2.1E-01* | |
| Cadmium | 1.1E-01 | 1.1E-01 | 1.1E-01 | ND | 0 |
| *TPE:* | *7.4E-02* | *7.5E-02* | *7.5E-02* | | |
| Copper | 9.5E+00 | 8.8E+00 | 4.4E+00 | 4.5E-01 | 0 |
| *TPE:* | *1.7E+01* | *1.6E+01* | *8.0E+00* | *8.1E-01* | |
| Iron | 1.6E+01 | 1.6E+01 | ND | ND | 0 |
| *TPE:* | *2.7E-02* | *2.7E-02* | | | |
| Lead | 4.2E-01 | 4.7E-01 | 4.7E-01 | ND | 0 |
| *TPE:* | *2.9E-01* | *3.2E-01* | *3.2E-01* | | |
| Manganese | 5.1E+00 | 5.1E+00 | 5.1E+00 | 5.7E+00 | 0 |
| *TPE:* | *3.1E+00* | *3.2E+00* | *3.2E+00* | *3.5E+00* | |
| Mercury | ND | ND | ND | 9.7E-03 | 0 |
| *TPE:* | | | | *1.1E+00* | |
| Naphthalene | 6.3E-01 | 6.9E-01 | ND | 9.5E-01 | 0 |
| *TPE:* | *2.9E-02* | *3.3E-02* | | *4.5E-02* | |
| Nickel | 5.3E+00 | 5.3E+00 | 4.0E+00 | 1.6E+00 | 0 |
| *TPE:* | *3.7E+00* | *3.7E+00* | *2.7E+00* | *1.1E+00* | |
| Nitrate/Nitrite | 1.4E+02 | 1.6E+02 | 9.6E+01 | ND | 0 |
| *TPE:* | 1.3E+01 | 1.5E+01 | 8.9E+00 | | |
| Oil and Grease (HEM[4]) | 1.3E+03 | 1.0E+03 | 3.1E+02 | 6.1E+02 | 0 |
| *TPE:* | | | | | |
| Phenanthrene | 5.4E-01 | 5.1E-01 | ND | ND | 0 |
| *TPE:* | *2.7E-01* | *2.6E-01* | | | |
| Selenium | 3.4E-01 | 3.4E-01 | 3.4E-01 | 1.7E-01 | 0 |
| *TPE:* | *2.7E-02* | *2.7E-02* | *2.7E-02* | *1.4E-02* | |
| Sulfate | 2.4E+04 | 2.3E+04 | 2.3E+04 | 2.1E+04 | 0 |
| *TPE:* | *1.3E-01* | *1.3E-01* | *1.3E-01* | *1.2E-01* | |
| Thallium | 7.3E-01 | 5.7E-01 | 5.7E-01 | 5.6E-01 | 0 |
| *TPE:* | *6.5E-01* | *5.1E-01* | *5.1E-01* | *5.0E-01* | |
| Total Sulfide | 1.4E+02 | 1.3E+02 | ND | 1.0E+02 | 0 |
| *TPE:* | *4.0E+02* | *3.5E+02* | | *2.9E+02* | |
| Zinc | 2.0E+01 | 2.1E+01 | 1.3E+01 | 8.8E-01 | 0 |
| *TPE:* | *1.4E+00* | *1.5E+00* | *8.8E-01* | *6.1E-02* | |
| **Total TPE Load** | **4.6E+02** | **4.1E+02** | **4.1E+01** | **3.1E+02** | **0** |

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT[2] |
|---|---|---|---|---|---|
| Freshwater: | | | | | |
| Cadmium | 1.5E-02 | 1.5E-02 | 1.5E-02 | ND | 0 |
| *TPE:* | *3.9E-02* | *3.9E-02* | *3.9E-02* | | |
| Copper | 1.3E+00 | 1.2E+00 | 5.9E-01 | 6.0E-02 | 0 |
| *TPE:* | *7.9E-01* | *7.3E-01* | *3.7E-01* | *3.7E-02* | |
| Iron | 2.2E+00 | 2.1E+00 | ND | ND | 0 |
| *TPE:* | *1.2E-02* | *1.2E-02* | | | |
| Lead | 5.6E-02 | 6.2E-02 | 6.2E-02 | ND | 0 |
| *TPE:* | *1.3E-01* | *1.4E-01* | *1.4E-01* | | |
| Manganese | 6.8E-01 | 6.8E-01 | 6.8E-01 | 7.5E-01 | 0 |
| *TPE:* | *4.8E-02* | *4.8E-02* | *4.8E-02* | *5.3E-02* | |
| Mercury | ND | ND | ND | 1.3E-03 | 0 |
| *TPE:* | | | | *1.5E-01* | |
| Naphthalene | 8.3E-02 | 9.2E-02 | ND | 1.3E-01 | 0 |
| *TPE:* | *1.3E-03* | *1.4E-03* | | *1.9E-03* | |
| Nickel | 7.1E-01 | 7.1E-01 | 5.3E-01 | ND | 0 |
| *TPE:* | *7.8E-02* | *7.7E-02* | *5.8E-02* | | |
| Nitrate/Nitrite | 1.9E+01 | 2.1E+01 | 1.3E+01 | ND | 0 |
| *TPE:* | 1.7E+00 | 2.0E+00 | 1.2E+00 | | |
| Oil and Grease (HEM[4]) | 1.7E+02 | 1.4E+02 | 4.1E+01 | 8.2E+01 | 0 |
| *TPE:* | | | | | |
| Phenanthrene | 7.2E-02 | 6.8E-02 | ND | ND | 0 |
| *TPE:* | *2.1E-02* | *2.0E-02* | | | |
| Selenium | 4.6E-02 | 4.5E-02 | 4.5E-02 | 2.3E-02 | 0 |
| *TPE:* | *5.1E-02* | *5.0E-02* | *5.0E-02* | *2.6E-02* | |
| Sulfate | 3.2E+03 | 3.1E+03 | 3.1E+03 | 2.8E+03 | 0 |
| *TPE:* | *1.8E-02* | *1.7E-02* | *1.7E-02* | *1.6E-02* | |
| Thallium | 9.8E-02 | 7.6E-02 | 7.6E-02 | 7.5E-02 | 0 |
| *TPE:* | *9.8E-02* | *7.6E-02* | *7.6E-02* | *7.5E-02* | |
| Total Sulfide | 1.9E+01 | 1.7E+01 | ND | 1.4E+01 | 0 |
| *TPE:* | *5.4E+01* | *4.7E+01* | | *3.8E+01* | |
| Zinc | 2.6E+00 | 2.8E+00 | 1.7E+00 | 1.2E-01 | 0 |
| *TPE:* | *1.2E-01* | *1.3E-01* | *7.9E-02* | *5.5E-03* | |
| **Total TPE Load** | **5.9E+01** | **5.3E+01** | **4.2E+00** | **4.1E+01** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-42. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Medium CI Ships (at or above 400 tons and under 6000 tons) (MCM 1 Based on LSD 41 Surrogate Data)**

| | Baseline Bilgewater | Primary Treatment | Primary Treatment Plus Filter Media[1] | Primary Treatment Plus Membrane Filtration[1] | CHT |
|---|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 14 | 14 | 11 | 8 | 0 |
| Total Number of Exceeded Numeric WQC | 96 | 93 | 88 | 32 | 0 |
| Number of Exceeded Narrative Categories | 8 | 8 | 4 | 7 | 0 |
| Discharge HI at EOMZ | 3.9E-01 | 3.6E-01 | 1.0E-01 | 1.9E-01 | 0 |
| Potential for NIS Release | Low | Low | Low | Low | None |
| Number of BCCs Identified | 7 | 7 | 5 | 5 | 0 |
| Discharge TPE (Saltwater) | 4.6E+02 | 4.1E+02 | 4.1E+01 | 3.1E+02 | 0 |
| Discharge TPE (Freshwater) | 5.9E+01 | 5.3E+01 | 4.2E+00 | 4.1E+01 | 0 |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water. The secondary treatment options provide bilgewater treatment performance that is superior for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. In addition, uncertainty due to potential variation in filter media performance because of channeling suggests that the filter media may not provide the environmental performance evidenced by these results. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration, or primary treatment plus filter media
3. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 MCM 1 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-43.

**Table 3-43. TPEs Removed for each MCPD Option and Associated Costs (MCM 1)**

| | Filter Media | Membrane Filtration | CHT |
|---|---|---|---|
| TPE removed from primary discharge by listed treatment | 3.90E+02 | 1.60E+02 | 5.30E+02 |
| Cost to non-USCG per TPE removed over primary treatment ($/yr) | $2,811 | $27,422 | $837 |
| *Each new vessel* | *$17* | *$181* | *$12* |
| Cost to USCG per TPE removed over primary treatment ($/yr) | $1,484 | $14,561 | $3,121 |
| *Each new vessel* | *$17* | *$188* | *$52* |

## 3.10 Small Compression Ignition Vessels (WPB 110)

Small ships are defined as vessels under 400 tons of displacement, and 65 ft or more in length. This group consists of more than 60 vessel classes including landing craft, patrol ships, torpedo trial craft, harbor tugs, and small buoy tenders. These ships have no more than four main propulsion CI engines. While smaller ships have auxiliary machinery, the size and amount of the equipment are substantially less than in ships over 400 tons. These vessels routinely operate within 12 nm from shore and in inland waters. However, some of the larger vessels in this group are designed as oceangoing vessels.

Ships in this vessel group receive fluids in the bilge mainly from condensation that forms on the interior hull and on piping, and from leaking pump packing glands, piping, valves, and flanges. The bilgewater of these ships may have oily constituents from DFM used for main engines and generators and lubricants such as 9250 lube oil (main engines and generators), 2190TEP lube oil (auxiliary equipment), hydraulic oil (elevators, cranes, and winches), and various grades of grease lubricants, used on pulleys, cables, valves, and other components.

### 3.10.1 WPB 110 Class Characterization

Characterization information was gathered on surface vessel bilgewater to support subsequent environmental effects and feasibility analyses. This information primarily included ship systems specifications and details regarding discharge composition. Ship systems data was acquired through process knowledge acquired from equipment experts.

Due to similarities in machinery, propulsion systems, and ancillary equipment, the LSD 41 vessel group discharge information is used to represent the WPB 110 vessel group.

Further information on the characterization of this discharge can be found in the respective chapter of the Bilgewater ChAR (Navy and EPA, 2003a).

### 3.10.2 WPB 110 Class Feasibility Impact

The feasibility impact analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-44.

**Table 3-44. WPB 110 Summary of Practicability and Operational Impact Analysis**

| MPCD Option | PRACTICABILITY AND OPERATIONAL IMPACT STUDY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Space and Weight | Personnel/ Equipment Safety | Mission Capabilities | Personnel Impact (operator labor hrs/year) | | Consumables, Repair Parts, and Tools | Interface Requirements | Control System Requirements | Other/ Unique Impacts |
| | | | | Within 12 nm (inc. maintenance) | Beyond 12 nm | | | | |
| Current MPCD* (Gravity Coalescer) | 12.5 $ft^3$<br>132 lbs (dry)<br>190 lbs (flooded)<br>No impact | No impact | No impact | 4.1 hrs | 0.39 hrs | None | Electrical power.—110/220VAC, 50/60Hz, 1 Phase | Automated control panel, remote tank level switches, and OCM | None |
| Centrifuge | 7 $ft^3$<br>132 lbs (dry)<br>OWS would be removed and replaced with unit | No impact | No impact | 9.85 hrs | 0.39 hrs | Minimal consumables and repair parts required | 440 VAC<br>Potable water- 1 gpd | Manual startup, OCM | None |
| CHT—operating from port with shoreside facilities | No impact—within current holding capacity | No impact | No impact | 1.2 hr | NA | None | None | None | None |
| CHT—operating from port without shoreside facilities | No impact—within current holding capacity | No impact | No impact | No impact | NA | None | None | None | None |
| Evaporation | **NF** – adequate space not available; excessive power requirements | | | | | | | | |
| Hydrocyclone | **NF** – compressed air not available | | | | | | | | |
| *In Situ* Biological Treatment | **NF** – cannot support batch treatment process | | | | | | | | |
| Oil Absorbing Socks | **NF** – potential safety (e.g., fire and flooding) hazard; solid waste handling impacts | | | | | | | | |
| Filter Media | **NF** – adequate space not available | | | | | | | | |
| Membrane Filtration | **NF** – adequate space not available | | | | | | | | |

**Table 3-45. WPB 110 MPCD Total Ownership Cost Comparison ($K/Vessel)**

| MPCD Option | Total Initial Inside 12 nm/ Inside+Beyond 12 nm | USCG Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | USCG Annualized Inside 12 nm/ Inside+Beyond 12 nm | USCG Total Ownership Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total 15-Yr Recurring Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Annualized Inside 12 nm/ Inside+Beyond 12 nm | Other Military Services Total Ownership Inside 12 nm/ Inside+Beyond 12 nm |
|---|---|---|---|---|---|---|---|
| Gravity Coalescence | 0/0 | 1.3/1.5 | .11/.13 | 1.3/1.5 | 1.0/1.1 | 0.09/0.09 | 1.0/1.1 |
| Centrifuge | 63.6/63.6 | 2.8/2.9 | 5.6/5.7 | 66.4/66.5 | 2.5/2.6 | 5.6/5.6 | 66/66.1 |
| CHT (within current holding capacity) | 0/0 | 28.66/28.66 | 2.436/2.436 | 28.66/28.66 | 2.63/2.63 | .223/.223 | 2.63/2.63 |

## 0.0.0 WPB 110 Class Environmental Effects

The environmental effects analysis of surface vessel bilgewater for this vessel group is summarized below in Table 3-46 and Table 3-47.

**Table 3-46. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Small Compression Ignition Ships (65 feet or more in length and under 400 tons of displacement) (WPB 110 Based on LSD 41 Surrogate Data)**

| Discharge Constituent | Strictest WQC | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | CHT[2] |
|---|---|---|---|---|---|
| **Saltwater:** | | | | | |
| Ammonia as Nitrogen | 2.3E+02 | 1.2E+03 | 1.3E+03 | 1.3E+03 | 0 |
| Copper | 2.4E+00 | 1.3E+01 | 1.5E+01 | 1.5E+01 | 0 |
| Iron | 3.0E+02 | 3.4E+02 | 3.3E+02 | 1.3E+02[3] | 0 |
| Lead | 5.6E+00 | 8.9E+00 | 9.8E+00 | 9.8E+00 | 0 |
| Manganese | 1.0E+02 | 1.1E+02 | 1.1E+02 | 1.1E+02 | 0 |
| Nickel | 8.3E+00 | 1.1E+02 | 1.1E+02 | 8.4E+01 | 0 |
| Phenanthrene | 5.0E+00 | 1.1E+01 | 1.1E+01 | ND | 0 |
| Thallium | 6.3E+00 | 1.5E+01 | 1.2E+01 | 1.2E+01 | 0 |
| Total Aqueous Hydrocarbons | 1.5E+01 | 7.4E+01 | 7.7E+01 | 7.7E+01 | 0 |
| Total Aromatic Hydrocarbons | 1.0E+01 | 2.4E+01 | 2.5E+01 | ND | 0 |
| Zinc | 5.0E+01 | 4.1E+02 | 4.5E+02 | 2.7E+02 | 0 |
| **Freshwater:** | | | | | |
| Cadmium | 1.1E+00 | 2.3E+00 | 2.4E+00 | 2.4E+00 | 0 |
| Copper | 8.8E+00 | 1.3E+01 | 1.5E+01 | 1.5E+01 | 0 |
| Zinc | 6.4E+01 | 9.8E+01 | 9.1E+01 | 9.1E+01 | 0 |
| **Number of Constituents exceeding strictest WQC** | **-** | **14** | **14** | **11** | **0** |
| **Total Exceeded Numeric Criteria** | **-** | **96** | **93** | **88** | **0** |

*[1] For new design consideration only. Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*
*[2] CHT does not release constituents to the receiving waters.*
*[3] Value does not exceed criteria.*

*ND = Not detected*

**Table 3-47. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) and Toxic Pound Equivalent Loading (TPE lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (WPB 110)**

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | CHT[2] |
|---|---|---|---|---|
| **Saltwater:** | | | | |
| Ammonia as Nitrogen | 1.9E+01 | 2.0E+01 | 2.0E+01 | 0 |
| *TPE:* | *1.6E-01* | *1.6E-01* | *1.6E-01* | |
| Cadmium | 3.6E-02 | 3.7E-02 | 3.7E-02 | 0 |
| *TPE:* | *2.4E-02* | *2.5E-02* | *2.5E-02* | |
| Copper | 3.1E+00 | 2.9E+00 | 1.4E+00 | 0 |
| *TPE:* | *5.6E+00* | *5.2E+00* | *2.6E+00* | |
| Iron | 5.3E+00 | 5.1E+00 | ND | 0 |
| *TPE:* | *9.0E-03* | *8.7E-03* | | |
| Lead | 1.4E-01 | 1.5E-01 | 1.5E-01 | 0 |
| *TPE:* | *9.6E-02* | *1.1E-01* | *1.1E-01* | |
| Manganese | 1.7E+00 | 1.7E+00 | 1.7E+00 | 0 |
| *TPE:* | *1.0E+00* | *1.0E+00* | *1.0E+00* | |
| Naphthalene | 2.1E-01 | 2.3E-01 | ND | 0 |
| *TPE:* | *9.6E-03* | *1.1E-02* | | |
| Nickel | 1.8E+00 | 1.8E+00 | 1.3E+00 | 0 |
| *TPE:* | *1.2E+00* | *1.2E+00* | *9.0E-01* | |
| Nitrate/Nitrite | 4.6E+01 | 5.3E+01 | 3.2E+01 | 0 |
| *TPE:* | *4.3E+00* | *4.9E+00* | *2.9E+00* | |
| Oil and Grease (HEM[4]) | 4.2E+02 | 3.4E+02 | 1.0E+02 | 0 |
| *TPE:* | | | | |
| Phenanthrene | 1.8E-01 | 1.7E-01 | ND | 0 |
| *TPE:* | *9.0E-02* | *8.6E-02* | | |
| Selenium | 1.1E-01 | 1.1E-01 | 1.1E-01 | 0 |
| *TPE:* | *8.9E-03* | *8.8E-03* | *8.8E-03* | |
| Sulfate | 7.8E+03 | 7.7E+03 | 7.7E+03 | 0 |
| *TPE:* | *4.4E-02* | *4.3E-02* | *4.3E-02* | |
| Thallium | 2.4E-01 | 1.9E-01 | 1.9E-01 | 0 |
| *TPE:* | *2.1E-01* | *1.7E-01* | *1.7E-01* | |
| Total Sulfide | 4.7E+01 | 4.1E+01 | ND | 0 |
| *TPE:* | *1.3E+02* | *1.2E+02* | | |
| Zinc | 6.4E+00 | 7.0E+00 | 4.2E+00 | 0 |
| *TPE:* | *4.4E-01* | *4.9E-01* | *2.9E-01* | |
| **Total TPE Load** | **1.5E+02** | **1.3E+02** | **1.4E+01** | **0** |
| **Freshwater:** | | | | |
| Cadmium | 3.6E-03 | 3.6E-03 | 3.6E-03 | 0 |
| *TPE:* | *9.4E-03* | *9.5E-03* | *9.5E-03* | |

| Discharge Constituent | Baseline | Primary Treatment | Primary Treatment Plus Filter Media[1] | CHT[2] |
|---|---|---|---|---|
| Copper | 3.1E-01 | 2.8E-01 | 1.4E-01 | 0 |
| *TPE:* | *1.9E-01* | *1.8E-01* | *8.9E-02* | |
| Iron | 5.2E-01 | 5.0E-01 | ND | 0 |
| *TPE:* | *2.9E-03* | *2.8E-03* | | |
| Lead | 1.4E-02 | 1.5E-02 | 1.5E-02 | 0 |
| *TPE:* | *3.1E-02* | *3.4E-02* | *3.4E-02* | |
| Manganese | 1.7E-01 | 1.7E-01 | 1.7E-01 | 0 |
| *TPE:* | *1.2E-02* | *1.2E-02* | *1.2E-02* | |
| Naphthalene | 2.0E-02 | 2.2E-02 | ND | 0 |
| *TPE:* | *3.1E-04* | *3.4E-04* | | |
| Nickel | 1.7E-01 | 1.7E-01 | 1.3E-01 | 0 |
| *TPE:* | *1.9E-02* | *1.9E-02* | *1.4E-02* | |
| Nitrate/Nitrite | 4.5E+00 | 5.2E+00 | 3.1E+00 | 0 |
| *TPE:* | *4.2E-01* | *4.8E-01* | *2.9E-01* | |
| Oil and Grease (HEM[4]) | 4.1E+01 | 3.3E+01 | 9.8E+00 | 0 |
| *TPE:* | | | | |
| Phenanthrene | 1.7E-02 | 1.7E-02 | ND | 0 |
| *TPE:* | *5.1E-03* | *4.9E-03* | | |
| Selenium | 1.1E-02 | 1.1E-02 | 1.1E-02 | 0 |
| *TPE:* | *1.2E-02* | *1.2E-02* | *1.2E-02* | |
| Sulfate | 7.7E+02 | 7.6E+02 | 7.6E+02 | 0 |
| *TPE:* | *4.3E-03* | *4.2E-03* | *4.2E-03* | |
| Thallium | 2.4E-02 | 1.8E-02 | 1.8E-02 | 0 |
| *TPE:* | *2.4E-02* | *1.8E-02* | *1.8E-02* | |
| Total Sulfide | 4.6E+00 | 4.1E+00 | ND | 0 |
| *TPE:* | *1.3E+01* | *1.1E+01* | | |
| Zinc | 6.3E-01 | 6.9E-01 | 4.1E-01 | 0 |
| *TPE:* | *3.0E-02* | *3.2E-02* | *1.9E-02* | |
| **Total TPE Load** | **1.4E+01** | **1.3E+01** | **1.0E+01** | **0** |

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000a), the use of a proxy value indicated that the contribution of this constituent to the total TPE value is relatively small.*

[4] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001c).*

*ND = Not Detected*

**Table 3-48. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Small Compression Ignition Ships (65 feet or more in length and under 400 tons of displacement) (WPB 110 Based on LSD 41 Surrogate Data)**

| | Baseline Bilgewater | Primary Treatment | Primary Treatment Plus Filter Media[1] | CHT |
|---|---|---|---|---|
| Number of Constituents exceeding strictest WQC | 14 | 14 | 11 | 0 |
| Total Number of Exceeded Numeric WQC | 96 | 93 | 88 | 0 |
| Number of Exceeded Narrative Categories | 8 | 7 | 4 | 0 |
| Discharge HI at EOMZ | 6.3E-02 | 5.8E-02 | 1.7E-02 | 0 |
| Potential for NIS Release | Low | Low | Low | None |
| Number of BCCs Identified | 7 | 7 | 5 | 0 |
| Discharge TPE (Saltwater) | 1.5E+02 | 1.3E+02 | 1.4E+01 | 0 |
| Discharge TPE (Freshwater) | 1.4E+01 | 1.3E+01 | 1.0E+01 | 0 |

[1] *For new design consideration only. Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus filter media (for new design consideration only)
3. Primary treatment only

Further information on the environmental effects analysis for this vessel group can be found in the respective chapter of the Bilgewater EEAR (Navy and EPA, 2003c).

### 0.0.0 WPB 110 Class Cost-Benefit Analysis

Cost benefit analysis for this vessel group is summarized below in Table 3-49.

**Table 3-49. TPEs Removed for each MCPD Option and Associated Costs (WPB 110)**

| | Filter Media | CHT |
|---|---|---|
| TPE removed from primary discharge by listed treatment | 1.47E+02 | 1.90E+02 |
| Cost to non-USCG per TPE removed over primary treatment ($/yr) | $0 | $408 |
| *Each new vessel* | *$73* | *$24* |
| Cost to USCG per TPE removed over primary treatment ($/yr) | $0 | $1,923 |
| *Each new vessel* | *$73* | *$36* |

# 0.0 SUMMARY

Surface vessel bilgewater was identified in Phase I of the UNDS program as a discharge requiring control with an MPCD. The vessels that produce this discharge were sorted into 13 vessel groups. For five of these vessel groups, a streamlined analysis was performed because these vessels can collect, hold, and transfer (to shore for treatment at a properly permitted facility) all bilgewater that otherwise would be discharged within 12 nm of shore.. The remaining eight vessel groups were subjected to a full analysis, including feasibility and environmental effects components. Four MPCD option groups were identified and screened for the treatment of bilgewater, including CHT, primary treatment (represented by gravity coalescence), filter media, and ultrafiltration.

The feasibility analysis of the four MPCD option groups (baseline was provided for comparison) culminated in a cost analysis of feasible options. These various costs can be found throughout this report. The only options deemed too impractical for consideration were the secondary treatment options (filter media and ultrafiltration) for the WHEC and WPB vessel groups.

The environmental effects analyses culminated in a ranking of MPCD options. The application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options generally provide bilgewater treatment performance that is equal or superior, for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

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